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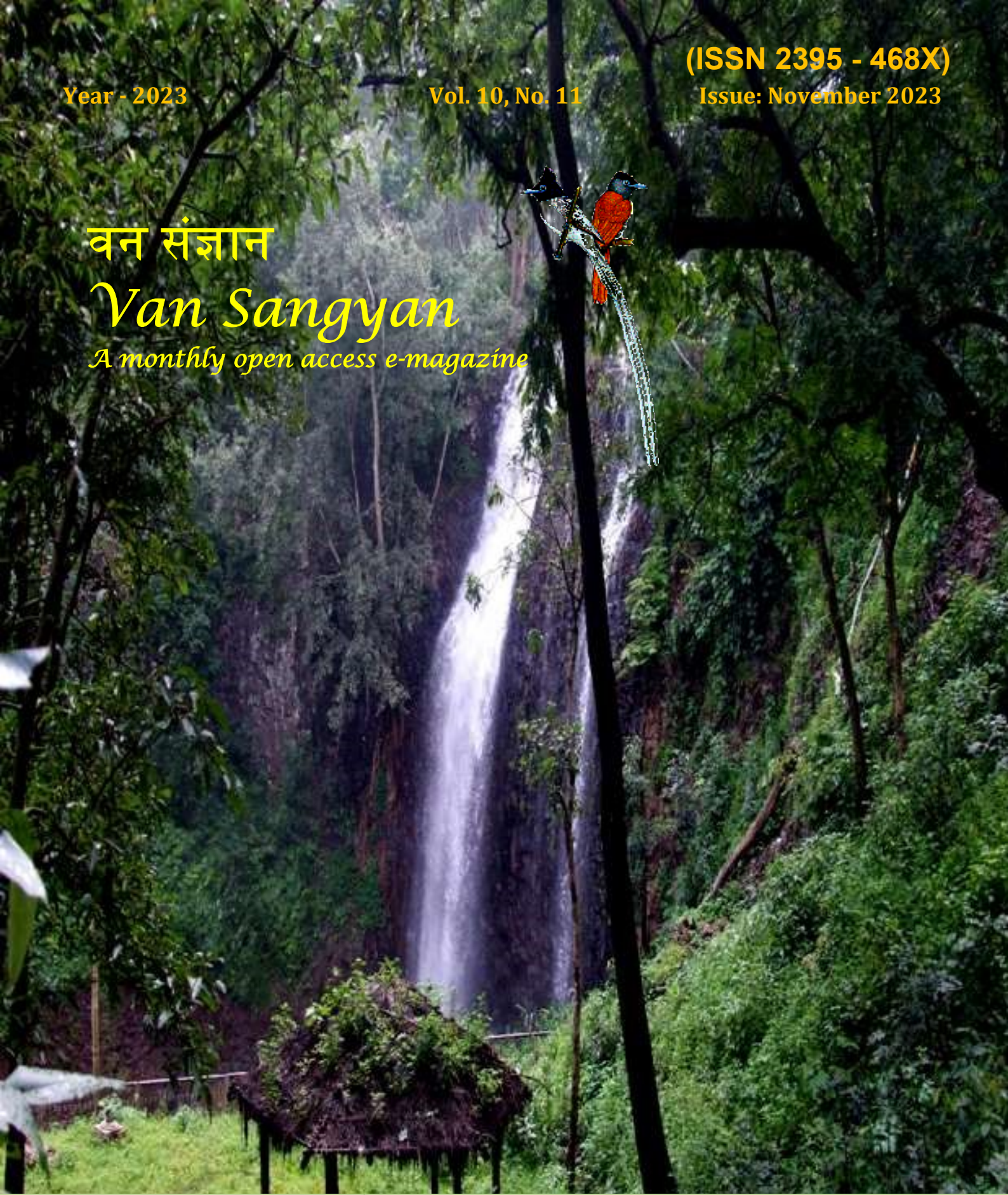

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Van Sangyan

Note to Authors:

We welcome the readers of Van Sangyan to write to us about their views and issues in forestry. Those who wish to share their knowledge and experiences can send them:

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or, through post to The Editor, Van Sangyan,
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The articles can be in English, Hindi, Marathi, Chhattisgarhi and Oriya, and should contain the writers name, designation and full postal address, including e-mail id and contact number. TFRI, Jabalpur houses experts from all fields of forestry who would be happy to answer reader's queries on various scientific issues. Your queries may be sent to The Editor, and the expert's reply to the same will be published in the next issue of Van Sangyan.

Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve

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From the Editor's desk

Toxic metal contamination of soil is a major environmental hazard. Chemical methods for heavy metal's decontamination such as heat treatment, electroremediation, soil replacement, precipitation and chemical leaching are generally very costly. Phyto-remediation stands as a promising and environmentally friendly solution to revegetate heavy metal-polluted land. In phyto-remediation, certain plants, known as hyperaccumulators, are strategically planted in polluted areas. These plants have the unique ability to absorb, accumulate, and sometimes even transform heavy metals within their tissues without showing significant signs of toxicity. This approach offers several advantages. First, it provides an environmentally friendly alternative to traditional remediation methods, such as excavation and soil replacement, which can be expensive and disruptive. Phyto-remediation also allows for the restoration of soil fertility and promotes revegetation, enhancing the overall ecological integrity of the affected area. Despite its potential benefits, phyto-remediation has limitations and may not be suitable for all types of pollutants or environmental conditions. Factors such as plant species selection, metal bioavailability, and site-specific characteristics need careful consideration for successful implementation. In conclusion, phyto-remediation stands as a promising and environmentally friendly solution to revegetate heavy metal-polluted land. By harnessing the unique abilities of certain plants, this approach contributes to the restoration of ecosystems, ensuring a more sustainable and harmonious coexistence between human activities and the natural environment.

In line with the above this issue of Van Sangyancontainsanarticleon Phyto-remediation: An ecologically sound approach to revegetate heavy metal polluted land.There are also useful articles viz., Opportunities for organic horticulture in India, Seaweed uses and the reasons for neglecting cultivation in India, Status of NTFP and it's role in livelihood in Chhattisgarh Tree and plants species for pollution management: A comprehensive review,Kigeliapinnata- Medicinal cum avenue tree: suitable for bund planting in riverbanks, Bamboo plantation through advanced method, चंदन की खेती, अकेसिया कटेचू का भौगोलिक वितरण एवं आर्थिक महत्व and Occurrence of larval parasitoids, Apanteles species in sal defoliator, Lymantria Mathura.

I hope that readers would find maximum information in this issue relevant and valuable to the sustainable management of forests.Van Sangyanwelcomesarticles, views and queries on various such issues in the field of forest science.
Looking forward to meet you allthrough forthcoming issues.

Dr. Naseer Mohammad

Chief Editor

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Phyto-remediation: An ecologically sound approach to revegetate heavy metal polluted land

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The accumulation of heavy metallic elements in soil has increased quickly as a result of a variety of anthropogenic (industrial) activities as well as natural processes. Heavy metals are persistent in the atmosphere due to their inability to biodegrade, have the potential to infiltrate the food chain through crop plants, and may eventually accumulate in people's bodies due to biomagnification. Toxic pollution by heavy metals is a serious threat to both the ecology and the welfare of society. A major problem for agricultural production and food safety is heavy metal contamination because of its harmful effects and quick buildup in the environment. Remediation of soil for the maintenance of ecosystem processes and functions is one of the greatest challenges facing our society today. Numerous physical, chemical, and biological methods have been used to remediate environmental pollution; however, their implementations are limited due to high cost and labour requirements, safety risks, and risks to ecosystems (Ali et al., 2013). Phytoremediation is a technique that has the potential to be effective and is acquiring popularity, acceptance, and implementation.

Phytoremediation, an environmentally benign method, is a cost-effective strategy for mitigating heavy metal contamination and revegetating contaminated soil. It incorporates the use of plants to extract and remove hazardous elemental pollutants and/or lower their bioavailability in soil. Plants, through their root system, have the potential to engross ionic complexes in the soil even at low concentrations. In order to accumulate heavy metals and regulate their bioavailability, plants spread their root systems into the soil matrix and create rhizosphere ecosystems, which stabilize soil fertility and allow for the reclamation of polluted soil. The simplest method for phytoremediation is the application of heavy metal hyperaccumulators, and hundreds of these plants have already been recognized. There are a number of phytoremediation techniques that can be used for the remediation of heavy metal-contaminated soils such as:

Phytostabilization

Metal-tolerant plant species are used to immobilize heavy metals underground and reduce their bioavailability. This prevents the metals from migrating into the ecosystem and mitigates the risk of metallic elements to enter into the food cycle. In order to meet the criteria of highly effective phytostabilization, plants should be tolerant to the effects of heavy

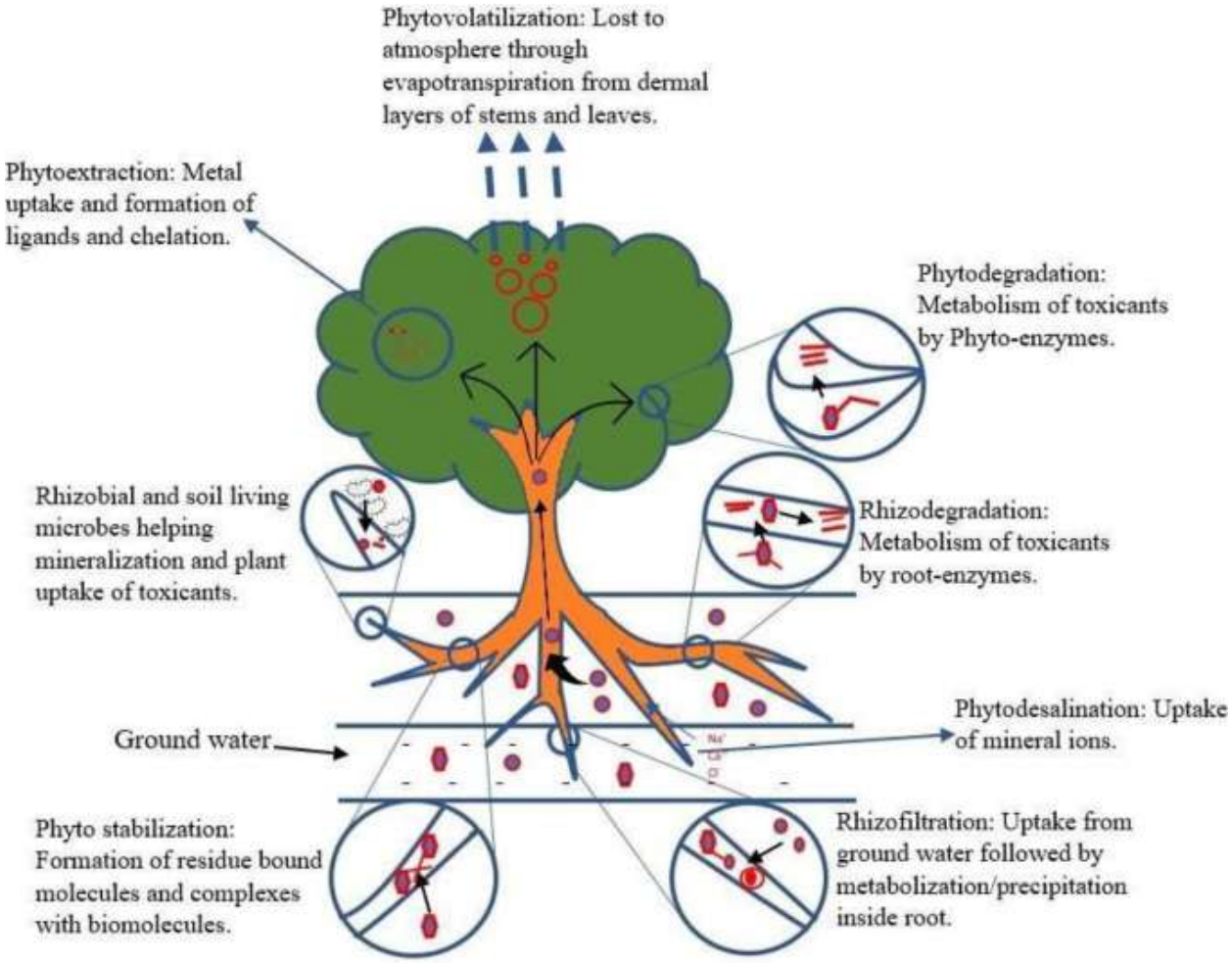

Fig: Phytoremediation processes and their associated functions

metallic elements and should have robust root systems since plant roots play pivotal role to immobilize heavy metals, stabilizing soil structure, and preventing soil erosion. Plant species such as *Jatropha curcas, Iris lacteal, Quercus ilex* and *Ricinus communis* have been identified as effective for Phytostabilization.

Phytoextraction

It is a method of phytormediation to extract and remove heavy metals from soil in which plants absorb contaminants from soil or water, and translocate and accumulate those contaminants in their aboveground biomass. The phytoextraction process of heavy metallic elements includes a few steps: (i) mobilization of hefty metallic elements in rhizosphere, (ii) uptake of metallic elements by plant roots, (iii) translocation of metallic elements or ions from roots to aerial parts of plant, (iv) sequestration and compartmentation of metallic elements or ions in plant tissues. Plant species used for the phytoextraction should have the following features. (i) Highly tolerant to the detrimental effects of heavy metals. (ii) High extraction ability with accumulation of high levels of heavy metals in aboveground parts, iii) fast growing with vigorous biomass production, plentiful shoots and widespread root system, decent adaptation to predominant environment,

robust to grow in deprived soils. Among these qualities, metal-accumulating capacities and aboveground biomass are the key features that determine the phytoextraction potential of a plant species. Robust biomass producing crops such as *Helianthus annuus, Cannabis sativa, Nicotiana tabacum,* and *Zea mays*, are identified as suitable crops for phytoextraction.

Phytovolatilization

In this technique plants absorb pollutants from soil, alter these lethal elements into less harmful volatile forms and then release those substances into the atmosphere through the transpiration mechanism of the leaves or foliage system. Organic pollutants and some other heavy metals (As, Se, Hg) can be detoxified using this method. Members of the Brassicaceae family such as *Brassica juncea*, *Brassica oleracea* are effective in volatilization of Se. Crops such as *Oryza sativa*, *Hordeum vulgare*, *Medicago sativa*, *Lycopersiconesculentum* and *Cucumis sativus* are suitable for Phytovolatilization. The benefit of phytovolatilization over the phytoremediation techniques is removing heavy metallic elements (metalloid) from the site and disbanding them as gaseous complexes, without any need for plant harvesting and clearance.

Phytofiltration

In this technique, mostly hydroponically cultured plants are used to adsorb heavy metallic ions from groundwater and aqueous waste. It includes the use of plant roots (rhizofiltration), shoots (caulofiltration), or seedlings (blastofiltration) to remove the impurities from polluted surface waters or waste water. Heavy metallic elements or ions are either absorbed by the roots or adsorbed onto the root surface during rhizofiltration. Aquatic plants such as cattail, azolla, duckweed, hyacinth, and poplar are usually used due to their substantial accumulation of lethal metals, high tolerance, or fast growth and vigorous biomass production. Terrestrial plants such as *B. juncea* and *H. annuus* are also identified as suitable species for Phytofiltration.

Advantages of phytoremediation:

(i) Economically viable since phytoremediation is an autotrophic system powered by solar energy, therefore, simple to manage, and the cost of installation and maintenance is low, (ii) environmentally and ecologically friendly—it can lessen pollution exposure to the ecosystem and environment, (iii) applicability—it can be applied over a large-scale field and can easily be disposed. (iv) It inhibits erosion and metal leaching through stabilizing heavy metals, reducing the threat of spreading pollutants. (v) It can also foster soil fertility by releasing various organic matters to the soil.

However, there are still some drawbacks to using these natural hyperaccumulators for phytoremediation because it is a time-consuming procedure that takes a very long time to clear up heavy metal-contaminated soil, especially in moderately and highly contaminated locations. This may be largely attributable to these hyperaccumulators' poor growth rate and low biomass production. Therefore, enhancing plant performance is a crucial step for developing successful phytoremediation. Fortunately, genetic engineering has become a potent technique

for modifying plants to have desired features like rapid growth and large biomass. Productivity, a high level of tolerance for the accumulation of heavy metallic elements and good climatic and geological adaptation. Therefore, a thorough understanding of how plants absorb, translocate, and detoxify heavy metals, as well as the identification and characterization of various molecules and signaling pathways, will be crucial for designing the best plant species for phytoremediation using genetic engineering.

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Opportunities for organic horticulture in India

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Introduction

Through the time of hunting and gathering through shifting cultivation, settled agriculture, and intense production to the present day of organic farming, agricultural production techniques have progressed steadily over time. Agriculture has a long history that is filled with inventions, hardships, and human attempts to raise food for themselves and their livestock. Before the 19th century, manures were utilized to create food, and horses and oxen were the primary sources of farm power because chemical fertilizers, insecticides, and tractors or other farm equipment were not yet developed. After the Green Revolution in the middle of the 1960s, India's own agricultural production successes have been outstanding and mostly because of greater usage of modern agriculture's key elements, such as high-yielding varieties, fertilizer, pesticides, and farm machinery.The world's most populous nation is India. The amount of arable land available is decreasing daily as a result of the growing population. The productivity of agricultural land and soil health must be increased in order to meet the rising population's demands for food, fiber, fuel, fodder, and other necessities. In the post-independence era, the Green Revolution provided developing nations with a roadmap for achieving food self-sufficiency, but the challenge of sustaining agricultural production in the face of limited natural resource demands has changed from "resource debasing"

chemical agriculture to "resource protective" biological or organic agriculture.

Current status

The majority of the world's organic growers are located in India, which has the greatest population. India exported 135 goods worth a total of $403 million during 2013 and 2014. The United States, the European Union, Canada, Switzerland, Australia, New Zealand, South-East Asian nations, West Asia, and South Africa were major markets for organic products coming from India. The majority of the goods and commodities shipped were soybeans, which made up 70% of them. Other products exported were cereals and millets besides basmati rice (4%), sugar (3%), tea (2%), pulses and lentils (1%), dried fruits (1%), and spices (1%).

Indian farmers and business owners are increasingly turning to organic farming, particularly in low-productivity regions,

rain-fed areas, mountainous regions, and the northeastern states where fertilizer usage is less than 25 kg/ha/year. In India, nine states have developed laws and initiatives pertaining to organic farming. In order to improve the economy and standard of living of its mountain farmers, Uttrakhand has made organic farming a priority. Mizoram and Sikkim announced that they would switch to entirely organic farming. Maharashtra, Tamil Nadu, and Kerala have backed public-private partnerships to advance organic farming, and Karnataka has developed organic policies.

Definitions of organic farming

According to the US Department of Agriculture, organic farming is "a system that is designed and mailed to produce agricultural products by the use of methods, and substances that maintain the integrity of organic agricultural products until they reach the consumer". In order to maintain long-term biological activity, ensure effective management, recycle waste to return nutrients to the land, provide attentive care for farm animals, and handle agricultural products without the use of extraneous synthetic additives or processing in accordance with the act and regulations, this is accomplished by using, where possible, cultural, biological, and mechanical methods rather than substances to fulfill any specific fluctuations within the system.

Funtilana (1990) stated that "Organic farming is giving back to the environment what has been taken from it." It is a farming method built on essential relationships, not only pure non-chemicalism. Soil, water, plants, microorganisms, and the overall interaction between the plant and animal kingdoms should all be understood. The foundation of organic farming is comprised of all of these relationships.

Key opportunities in India

An estimated 10% of the world's fruit production is produced in India, one of the top producers in the globe. Fresh, domestic product is largely consumed. Middle East, European, and Southeast Asian countries are the primary destinations. India is the world's greatest producer of mangoes, but due to high domestic demand, only a small fraction of its fresh and processed mangoes (42,998.31 MT) are exported. A market for organic mangoes exists in the UK, Netherlands, and Germany that India may try to take advantage of. India exports very little of its organic bananas to the global market. To increase exports of organic bananas, India must employ a two-pronged strategy. The market for processed organic bananas (pulp, purees, and concentrates) should be the first area of concentration, followed by the EU and the geographically nearby Japanese markets.

Since the U.S., the EU, and Japan are India's three main importing markets, there is good potential for the export of organic pineapples from India. The Middle East is India's main export market for grapes, as it is for the majority of other fruits, although there are few chances for organic grapes there. The EU, particularly the UK and the Netherlands, is the primary target destination market for Indian organic grapes. Additionally, there is a contemporary consumption trend that favors organic wine more and more, which raises the demand for organic grapes. Litchi, passion fruit, pomegranate, sapota,

apple, walnut, and strawberry are additional organic fruits that could be shipped effectively.

After China, the Middle East, Singapore, Malaysia, Sri Lanka, Bangladesh, Nepal, the EU, and Australia are the other top vegetable-producing nations in the world. Asparagus, celery, paprika, sweet and baby corn, cherry tomatoes, and other non-traditional vegetables are all exported along with traditional veggies like onion, potato, okra, bitter gourd, and green chilies. Veggies grown organically are in greater demand worldwide, and Indian growers of organic veggies might increase their market share in the EU, Australia, and Singapore. Organic tea is also primarily produced and exported by India. The European Commission has awarded "equivalence" status to Indian organic certifying agencies, allowing Indian organic tea growers to extend their markets in Europe, one of the biggest markets worldwide.Most developed nations, including the U.S., Germany, France, Italy, Japan, and the EU, eat organic coffee. India's share of the global organic coffee market is anticipated to be 1%, thus there is a significant opportunity to boost exports in the short term. Currently, India makes up approximately 12% (in terms of volume) of the global spice market. Germany, the UK, France, Japan, and the U.S. are the top five countries for purchasing organic spices. However, the percentage of organic spices in India's total spice production is incredibly small. Pepper, ginger, turmeric, cloves, mace, nutmeg, vanilla, cardamom, chili, mustard, tamarind, camboge, thyme, rosemary, oregano, marjoram, parsley, and sage (fresh, dehydrated, and oil) are among the organic spices produced by India that have export potential.India, which has a large area dedicated to the cultivation of medicinal and aromatic plants, is a significant provider of certified organic components to the international organic cosmetics and health care sectors. India also contributes significantly to global essential oil production. Given these benefits, India may rise to prominence as a major supplier of organic components to the international organic beauty and pharmaceutical industries.

The four principles of organic agriculture are as follows

The principle of health

The health of the soil, plants, animals, and people should be sustained and improved by organic farming as a whole.

The principle of ecology

Based on live ecological processes and cycles, organic agriculture should cooperate with them, imitate them, and contribute to their sustainability.

The principle of fairness

Organic farming should be based on connections that guarantee fairness with regard to the shared environment and opportunities for life.

The principle of care

In order to safeguard the health and welfare of present and future generations as well as the environment, organic agriculture should be managed with caution and responsibility. Although the sustainable development of mankind is not expressly stated in the fundamental principles, they give organic farming a foundation for guaranteeing the health of the environment.

Certification and legislation of organic food in India

The following six accredited accreditation agencies are currently recognized in India by the Ministry of Commerce, Government of India. Those are

- APEDA (Agricultural & Processed Food Product Export Development Authority).
- Coffee Board
- Spices Board
- Tea Board
- Coconut Development Board
- Cocoa & Cashew nut Board

In addition there are four Certification Agencies accredited by APEDA such as

- IMO Control Pvt. Ltd., Bangalore (Institute fur Market ecologie, Switzerland)
- Skal International (The Netherlands), India, Bangalore
- SGS (SocieteGenerale de Surveillance, Switzerland) India Pvt. Ltd., Gurgaon
- ESCOCERT (Ecological Certification, France) International, Germany

The Indian Organic emblem is promoted internationally by APEDA, an organization that promotes exports of agricultural and processed food products. By raising awareness through active participation in international conferences, Expo-Import Bank and APEDA are promoting organic agriculture products. Additionally, it has begun to identify special Agri Export Zones (AEZ) for organic produce in specific regions of the nation, such as Tripura, where organic pineapple is grown with little to no usage of chemical pesticides and fertilizers. NSOP (National Standards for Organic Production): It was developed for the National Program for Organic Production (NPOP) by the Department of Commerce, Government of India.The term "Organic" may be used by any production that has received NSOP certification. When a product has been made in India to an organic standard other than NSOP, such as EU regulations, IFOAM, etc., it may be marked "For export only." For domestically manufactured organic goods that adhere to the NSOP and worldwide organic standards, truthful label claims are permitted. Organic Certificates were good for a year or until the following choice was made. When you suspend your certification voluntarily or when the certification agencies suspend it, the organic certification standards become invalid. Typically, inspections take place once a year. Inspecting is done again wherever it is deemed essential.The NSOP has established guidelines regarding the improper usage of the term "Organic". Any business that intentionally markets or labels a product as "Organic" while not adhering to the National Standards could face civil liability. In order to provide trustworthy and reasonably priced organic inspection and certification services to farmers, processors, input suppliers, and merchants, India's first local organic certification body, INDOCERT (Indian Organic Certification Agency), was founded in March 2002. It is a nonprofit organization that is independent and operates across the country with the main goal of conducting inspections and awarding certification for organic agriculture practices. It offers certificates for both domestic and international markets.Additionally, INDOCERT serves as a forum for networking, information sharing, raising awareness, and training in

the area of organic farming. It was established by a number of corporate and NGOs in India with technical assistance from FiBL, bio-inspecta, and the Swiss State Secretariat of Economic Affairs (SECO). Two reputable Swiss institutions, FiBL (Research Institute of Organic Agriculture) and bio.inspecta (the top Swiss certification body) have close technical partnerships with INDOCERT. Through a re-certification process, Bio.inspecta assists INDOCERT with certification in accordance with the USDA National Organic Program (NOP) and JAS (Japanese Agricultural Standard for Organic Agriculture). It assesses inputs used in organic farming and verifies their adherence to both the European Regulation EC 2092/91 and the Indian National Organic Standards. Currently, INDOCERT limits its input approval scheme to inputs linked to plant protection (pesticides, repellents, etc.) as well as fertilizers and soil conditioners.

Conclusion

India's organic export markets would grow with the support of the industry, the government, and NGOs coming together to work with farmers. The future for markets for organic foods is definitely bright, as it is growing rapidly in the EU, in the U.S. and Canada, and in Japan and Australia, as well as in some developing countries. With growing consumer awareness of food safety, health, and environmental issues, the organic food sector has become an attractive opportunity for export from developing countries.

Seaweed uses and the reasons for neglecting cultivation in India

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Introduction

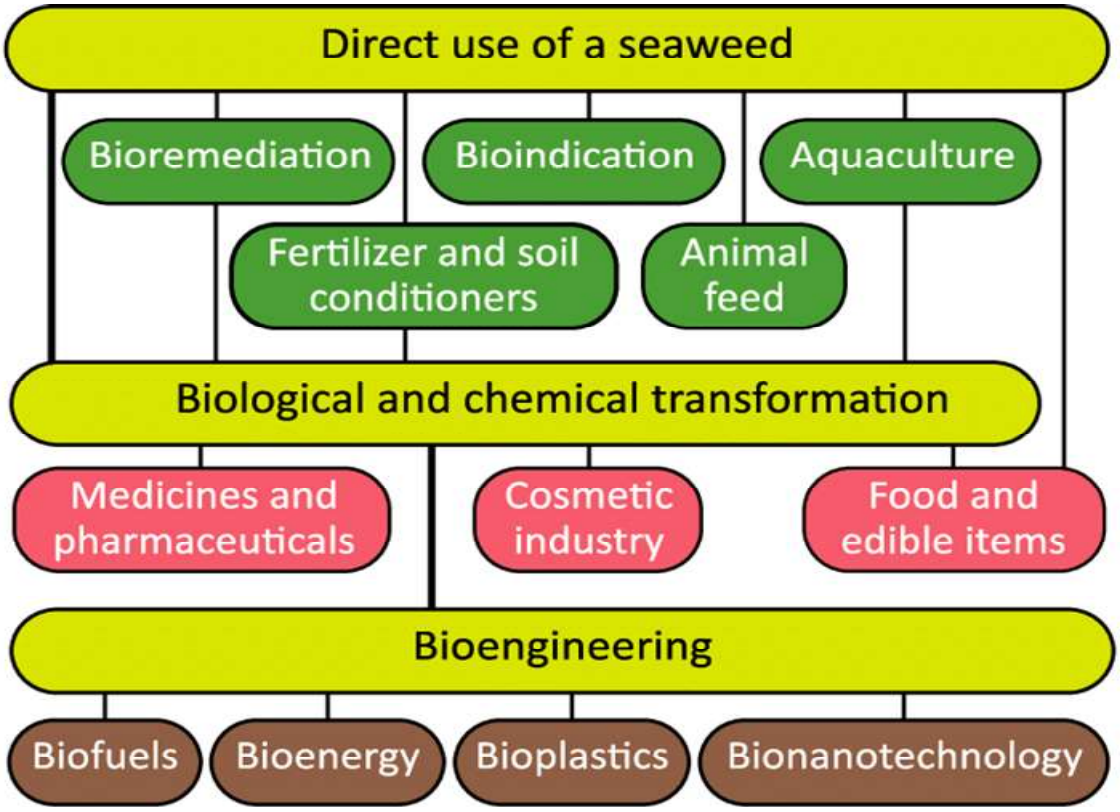
Oceans constitute about two thirds of the earth's surface, and photoautotrophic organisms, commonly referred to as algae, live in their top layers. Marine seaweeds have been identified as an important group of organisms that are essential to the health of coastal ecosystems. The group of plants known as seaweeds, sometimes known as benthic marine algae or macroalgae, may be found in both brackish and saltwater environments.Seaweeds have pigments that are used in photosynthetic processes, just like terrestrial plants, and they make food through photosynthetic processes when exposed to light and nutrients in water. They are regarded as an essential biological and ecological component of marine ecosystems. Seaweeds significantly contribute to marine primary production and offer habitat for nearshore benthic organisms(Williams & Smith, 2007). These enormous underwater forests, known as kelps, grow on rocky coastlines and have a structure like that of terrestrial forests. They play a significant role in coastal biodiversity by providing a variety of habitats and breeding grounds for vast numbers of creatures, such as fishes and crustaceans. They are often divided into three groups: Rhodophyceae (red algae), Phaeophyceae (brown algae), and Chlorophyceae (green algae). Around 10,000 different types of seaweeds, with a potential global production of 7.5-8 million tonnes (wet weight), are produced along the world's coastlines(McHugh, 2003).

Rich seaweed beds can be found around Visakhapatnam in the eastern coast, Mahabalipuram, the Gulf of Mannar, Tiruchendur, Tuticorin, and Kerala in the southern coast, Veraval and the Gulf of Kutch in the western coast, and the Andaman and Nicobar Islands and Lakshadweep. Seaweeds are particularly abundant along the coastline, especially in rocky shore regions (Silva et al., 1996; Sahoo, 2001).

Over 220 genera and 740 species of marine algae were found in India, 60 of which had commercial value. There are 180 different types of seaweed growing in the Mandapam region of Tamil Nadu, and around 40 of them are economically valuable. (Kolanjinathan, 2014). In India, brown algae *Sargassum spp, Turbinariaspp, and Cystoseiratrinodis* are cultivated to produce alginates and liquid seaweed fertilizer. Red algae *Gelidiellaacerosa, Gracilaria edulis, G. crassa, G. foliifera, and G. verrucosa* are cultivated for the manufacture of agar.

Uses of seaweeds

Seaweeds have a substantial impact on human cultural and economic systems by



Various applications of Seaweeds

providing ecosystem products and services such as food, medicine, and natural protection. Seaweeds are economically significant not just as the foundation of a productive food web, but also as major habitat structuring agents, like corals and trees, which harbor immense biodiversity and are commercially useful. Seaweeds are considered to provide coastal communities with a greater potential to prosper and maintain a sustainable way of life.

Seaweeds are nothing more than the ocean's richness, or we might say that they are a type of marine resource. It's an excellent source of fibre, proteins, carbohydrates, vitamins, minerals, and other nutrients. They can be used as a raw material for the manufacturing of agar, algin, and carrageenan. These macroalgae are botanically referred to as macrophytic marine algae because they possess several antibacterial, antialgal, antimacrofouling, and antifungal qualities that are useful in the prevention of biofouling.

Diverse species of seaweed are rich in minerals including sodium, calcium, magnesium, potassium, chlorine, sulphur, phosphorus, and micronutrients like iodine, iron, zinc, copper, selenium, molybdenum, fluoride, manganese, boron, nickel, and cobalt. It is also a rich source of iodine, which is usually found in brown seaweed.

In addition to various herbal remedies, it has been claimed that seaweeds offer healing properties for the treatment of TB, arthritis, colds, and influenza. There are anti-inflammatory and anti-microbial compounds in many different species of seaweed. They have been used for

thousands of years for therapeutic purposes; the ancient Romans used them to heal burns, rashes, and wounds. They are also thought to contain potent cancer-fighting compounds (Pati et al., 2016).

Seaweeds, or macroalgae, are an important part of the primary biomass produced in coastal marine ecosystems and serve as a vital biological resource for invertebrates, fish, mammals, and birds. They could also prevent coastal erosion.

They provide an alternate supply of manure to expensive commercial fertilizers and can be utilized as food for humans, animal feed, or plant manure. They can also be used as a source of various chemical compounds.Products made from seaweed are used in some way or another in our everyday lives (e.g., seaweed polysaccharides are employed in the manufacture of toothpastes, soaps, shampoos, and cosmetic products such as creams and lotions and also as a source for animal nutrition). Moreover, it is utilised in the paper industry, medicinal research, and wastewater treatment(CruzSuarez et al. 2010).

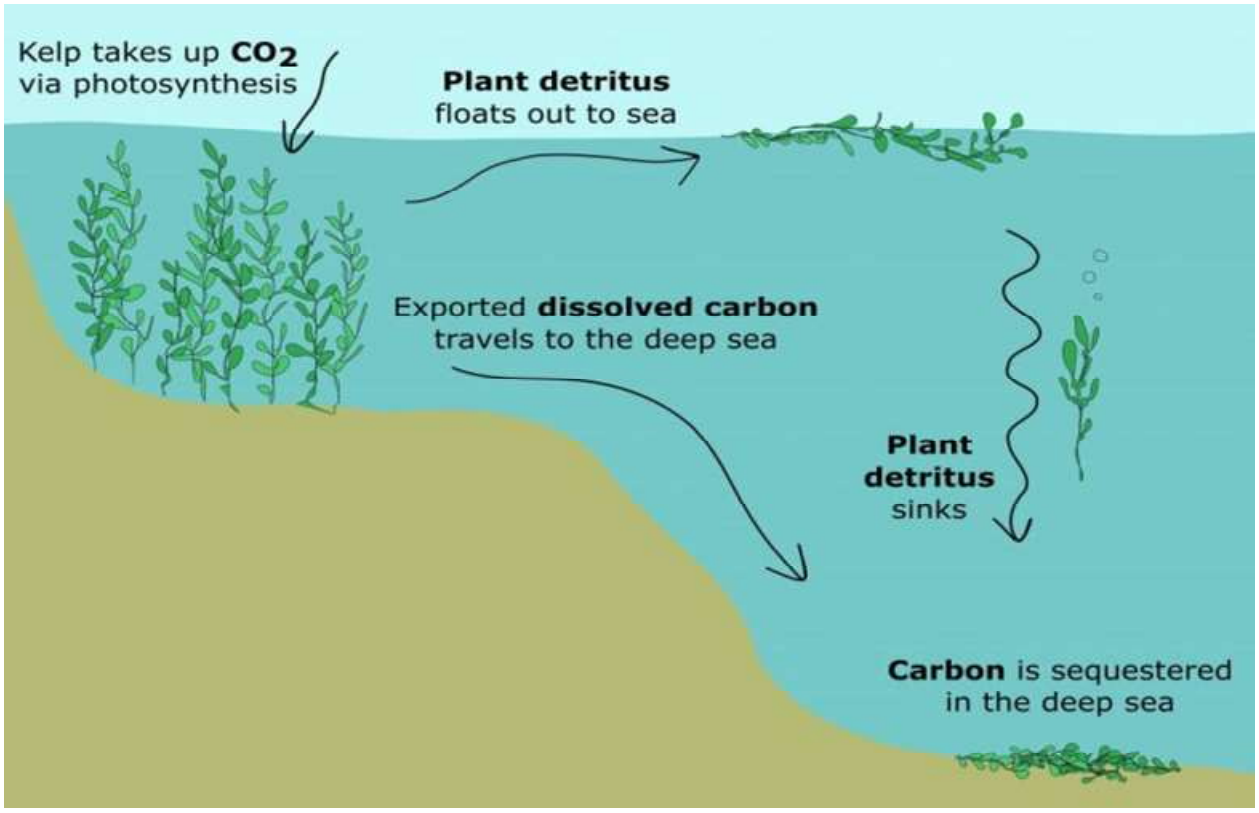
In addition, biofuels, which are fuels made entirely from living things, may be made from these macroalgae. This implies that it can offer a more environmentally friendly substitute for fossil fuels like petroleum, which release carbon.

Role in Carbon sequestration

Mitigating anthropogenic greenhouse gas (GHG) emissions is a challenging and potentially grave challenge in our attempts to address climate change. As seaweed and algae are excellent carbon sinks—that is, they absorb more carbon than they emit—they have been proposed as a possible source to combat global warming. In addition to serving as a substantial carbon sink, using anthropogenic CO_2 as an industrial byproductfor the production of seaweed has enormous potential for assisting to partially meet the world needs for food, fodder, fuel, and pharmaceuticals. Carbon fixation by photoautotrophic and macroalgae has the potential to reduce CO_2 emissions into the atmosphere and aid in mitigating global warming. Carbon dioxide removal from the atmosphere by seaweeds is a marine climate intervention strategy that, if successful, would remove atmospheric CO_2 emitted by human activity. Seaweeds take in CO_2 via blades, which resemble leaves, and fix $CO_2$with the help of the enzyme RuBisCO at rates like terrestrial plants(Mann 1973).

Seaweeds are efficient carbon sinks because of their special properties. Seaweeds synthesize organic matter, including sugars and proteins, by absorbing CO_2, water, and sunlight during photosynthesis. Seaweeds have the capacity to fix up to 20 times more carbon per unit area than land-based plants, and certain species can absorb huge amounts of CO_2. The biological pump is one of the main mechanisms through which seaweeds store carbon. Seaweeds that die sink to the ocean floor and are buried under sediment. This method efficiently removes carbon from the atmosphere by sequestering it for hundreds or even thousands of years. Seaweeds play a significant role in driving the biological pump, a critical component of the ocean's carbon cycle.

Moreover, seaweeds can reduce the impacts of ocean acidification. The oceans absorb more CO_2 as atmospheric CO_2 levels rise, which lowers the pH of



Biological Pumping of Carbon to deep sea

seawater. The capacity of organisms that make shells to do so may be negatively impacted by this process, known as ocean acidification, which can harm marine life. Seaweeds serve to maintain a healthy marine environment by absorbing extra CO_2 from the water during photosynthesis, which helps to mitigate the consequences of ocean acidification.

Why the Seaweed Cultivation is being neglected?

Seaweeds are threatened in developing nations as they are harmed by several human activities. The need for cultivation for a variety of uses is driven by rising concern over the loss of seaweed resources and changes to the diversity of various living forms. Large-scale mariculture of seaweeds, particularly of economically important species, can yield a significant amount ofbiomass that can be harvested for industrial uses while also somewhat reducing the atmospheric concentration of CO_2.

In India, Seaweed farming is being neglecting for a variety of reasons which includes:

India is still in the experimental stage of seaweed farming, while several commercial seaweeds have been tried in the field. Such cultivation has been brought about by overuse combined with a shortage of seaweeds on the one hand, and their loss as a result of cyclones and other natural disasters on the other.

Lack of awareness and understanding of the potential advantages of seaweed is one of the main causes of seaweed farming being neglected in India. In some regions of the country, seaweed has long been

utilized as a source of fertilizer, but its significance as a source of food and animal feed is less well recognized. Due to a lack of investment in the area's research and development, the industry's expansion has been constrained.

The absence of infrastructure and support systems in India is a major impediment to the cultivation of seaweed. Access to suitable coastal regions, specific tools, and knowledge are necessary for seaweed production. Also, seaweed farmers struggle to grow their operations and compete with other agricultural products due to a lack of institutional and financial assistance.

Regulatory barriers also pose a major barrier to seaweed production in India. Seaweed farming is regulated by a complicated framework of regulations that fluctuate between jurisdictions, making it difficult for farmers to negotiate the system. Furthermore, there is a lack of clear guidelines on matters like licensing, permits, and environmental impact assessments, which might discourage farmers from entering the market.

Additionally, environmental problems such as pollution and climate change are a threat to seaweed farming in India. Seaweed ecosystems have been deteriorated by coastal pollution, and seaweed farms may be damaged by increasingly frequent and severe weather events brought on by climate change.

As seaweed harvesting requires collecting the plants from depths more than 25 to 30 feet, it is risky.

India has a wide variety of seaweeds; however, we solely focus on harvesting rather than cultivation, which results in over-exploitation.

In conclusion, seaweeds contribute significantly to carbon sequestration and the health of marine ecosystems. They are an important resource in the battle against climate change due to their capacity to absorb and store vast amounts of CO2, maintain biodiversity, and mitigate the impacts of ocean acidification. Seaweeds are expected to have a greater influence in our attempts to reduce the consequences of climate change as we continue to create new technologies and methods for lowering greenhouse gas emissions.

The neglect of seaweed farming in India is a complicated issue that requires a diversified solution. Addressing the lack of awareness and knowledge about the potential advantages of seaweed, as well as providing infrastructure and support systems, might assist to promote the growth of the seaweed sector. Additionally, it may be possible to improve the environment for seaweed farmers by simplifying rules and addressing environmental issues. Seaweed farming has the potential to be a valuable and long-lasting source of income for Indian coastal communities with the right policies and investments.

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Parasitic plants: An overview

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Introduction

More than 1% of all angiosperm species—or around 4500—are parasitic; they depend on their host plants for all or part of their water and nutrients (Kuijt, 1969; Heide-Jrgensen, 2008).The majority of plants are photoautotrophic organisms, which means that only basic abiotic resources are required for their fundamental physiological functions. Parasitic plants are an exception to this rule since they obtain nutrients by parasitizing other plants through a unique organ called the haustorium. Haustoria, which are developed as root or stem alterations, secure unidirectional connections between the vascular systems of the host and parasite, permitting resource flow and releasing parasitic plants from several development restrictions. A number of parasitic plant species attack cultivated crops or timber-producing trees.In the world's primary biomes, parasitic plants are widely scattered. With the exception of Antarctica, they can be found anywhere from high-latitude Arctic tundra to low-latitude tropical rainforests (Joel et al., 2015).Chlorophyll content can be used to distinguish parasitic plants from other types of plants. Hemiparasites, sometimes known as semiparasites, are organisms that make chlorophyll and hence have some capacity for photosynthetic activity. According to how dependent they are on the host, hemiparasites can be further classified into two types: facultative and obligatory. Facultative hemiparasites are photosynthetic, and when they come into contact with host roots, they consistently make haustorial connections despite not needing a host to complete their life cycle. On the other hand, obligate parasites must have a host in order to develop and start a haustorium. These parasites use direct, cell-to-cell contacts to the xylem to directly take water and dissolved minerals from the host roots. Facultative hemiparasites are present in a number of root-parasitic families, such as the Olacaceae, Opiliaceae, Santalaceae (Santalales), Krameriaceae (Fabales), and Lamiales (Weber 1981; Mann and Musselman 1981). Holoparasites are those that lack chlorophyll, are not green, and completely rely on their host for nourishment and water. While some parasitic plants only infect roots, others only target stems. They are simply known as stem parasites and root parasites, respectively. (Kuijt 1969)

Haustoria of parasitic plants

A hemispherical, multicellular organ called the haustorium invades the host tissue in order to absorb nutrients and water. The haustoria can be classified as terminal or lateral depending on where they develop on the parasite's root (Kuijt,

1969). The production of multiple

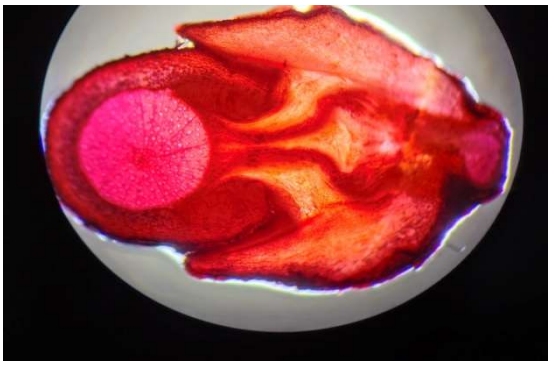

Fig 1: Depicting Haustoria formation between parasitic plant and Host plant

haustoria and continuous root tip extension are made possible by the emergence of lateral haustoria at the root elongation zone (Ishida et al., 2011, Matvienko et al., 2001). The formation of terminal haustoria at the tip of the root stops growth of roots (Joel and Losner-Goshen, 1994). According to Bandaranayake et al. (2010), these haustoria-inducing factors (HIFs) start a signal transduction cascade that results in a buildup of reactive oxygen species (ROS) in the parasitic root and the development of the haustorium.

Stages in life cycle of a parasitic plant (Sun et al., 2007)

Germination

- The life cycle of a parasitic plant begins with the germination of its tiny seeds.
- The seeds are usually dispersed by various means, such as wind, water, or animals.

Attachment

- After landing on the host plant, the seed sends out a specialized structure called a haustorium.
- The haustorium attaches to the host plant and penetrates its tissues.

Parasitic Stage

- Once attached, the parasitic plant establishes a connection with the host's vascular system.
- It begins to extract water, nutrients, and sometimes even carbohydrates from the host.

Growth and reproduction

- As the parasitic plant continues to draw nutrients from the host, it grows and develops.
- It produces stems, leaves (if present), and flowers (in some species).

Flower and seed production

- When the parasitic plant matures, it produces flowers that may have
- unique adaptations to attract pollinators.
- Successful pollination leads to the formation of seeds.

Seed dispersal

- Once the seeds are mature, they are dispersed to find new host plants or suitable environments for germination.
- This completes the life cycle, and the process starts a new with seed germination.

Nutrient balance between parasitic plant and host plant

Through a unique structure known as the haustorium, parasitic plants receive nutrients and other resources from their hosts (Press and Graves, 1995; Press, 1998). According to Estabrook and Yoder (1998), haustorium creates a xylem and/or phloem link between the parasite and host plant and directs the unidirectional flow of resources to the parasite plant. The proximity of the xylem vessels of the host and parasite, direct luminal interaction between the xylem, or specialized

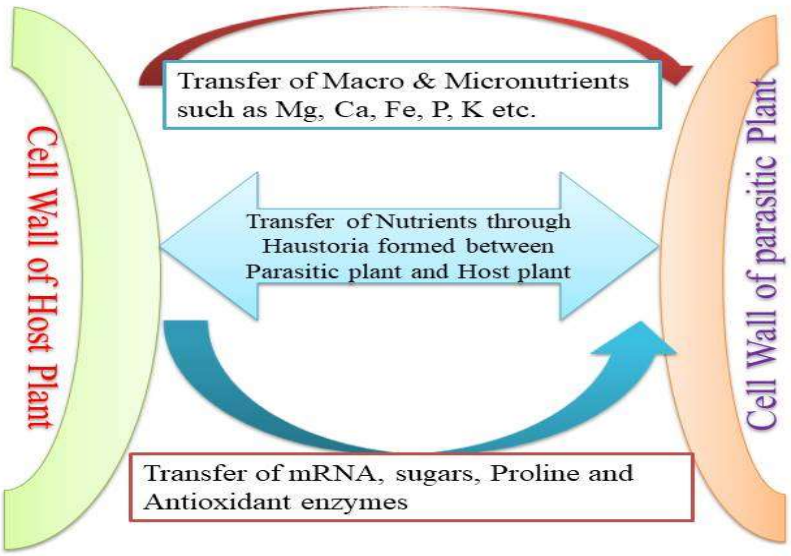

Fig 2: Depicting Nutrient transfer between parasitic plant and host plant

Table 1: List of important parasitic plants

Aquatic Parasitic Plants			
Common Name	**Scientific Name**	**Host Plant(s)**	**Habitat**
Water Hyacinth	*Eichhorniacrassipes*	Free-floating plants	Freshwater lakes, ponds, and rivers
Water Fern	*Azolla spp.*	Aquatic ferns	Still or slow-moving water bodies
Bladderwort	*Utricularia spp.*	Small aquatic organisms	Freshwater lakes, ponds, and marshes
Coconut Mistletoe	*Erianthemumareolatum*	Coconut palm trees	Coastal regions in the tropics
Water Dodder	*Cuscutagronovii*	Submerged aquatic plants	North America, temperate regions
Swamp Dodder	*Cuscutasuaveolens*	Wetland plants	North America, wetland habitats
Hemi-parasitic Plants			
Common Name	**Scientific Name**	**Host Plant(s)**	**Habitat**
Yellow Bartsia	*Parentucelliaviscosa*	Various plants	Europe, North Africa, Southwest Asia

Eyebright	*Euphrasia spp.*	Grasses and other plants	Temperate regions
Cowbane	*Selinum spp.*	Various plants	Temperate and subtropical regions
Western Australian Christmas Tree	*Nuytsia floribunda*	Various plants	Southwest Australia
Purple Broomrape	*Orobanchepurpurea*	Various plants	Europe, Asia, North Africa, North America

Australian Parasitic Plants

Common Name	Scientific Name	Host Plant(s)	Habitat
Christmas Mistletoe	*Amyema spp.*	Various trees and shrubs	Australia, commonly found in woodlands
Australian Leafless Mistletoe	*Dendrophthoe spp.*	Eucalyptus and other trees	Australia, found in various ecosystems
Bent-leaf Mistletoe	Muellerinaeucalyptoides	Acacia and eucalyptus trees	Eastern Australia, subtropical regions
Sandalwood	*Santalum spp.*	Various tree species	Australia, Pacific Islands, Southeast Asia
Snakeweed	*Cassytha spp.*	Various host plants	Australia, found in diverse habitats

Epiphytic Parasitic Plants

Common Name	Scientific Name	Host Plant(s)	Habitat
Leafless Bromeliad	*Bromeliohyla species*	Trees and shrubs	Tropical regions, Central and South America
Beechdrops	*Epifagusvirginiana*	American beech trees	Eastern North America
Oak Mistletoe	*Phoradendronserotinum*	Oak trees	North America
Orchid Mistletoe	*Gymnadeniaconopsea*	Grasses and orchids	Europe, North America

Neo-tropical Parasitic Plants

Common Name	Scientific Name	Host Plant(s)	Habitat

Amazon Mistletoe	*Dendrophthorafastuosa*	Various trees and shrubs	Amazon Rainforest
Andean Mistletoe	*Tristerixtetrandus*	Trees of Prumnopitysgenus	Andean forests of South America
Spanish Moss	*Tillandsiausneoides*	Trees and shrubs	Southeastern United States, Central America
Guianan Mistletoe	*Tripodanthusacutifolius*	Various host plants	Guiana Shield (northern South America)
Holo-parasitic Plants			
Common Name	**Scientific Name**	**Host Plant(s)**	**Habitat**
Cancerroot	*Orobanche species*	Various plants	Worldwide, diverse habitats
Pholisma	*Pholisma spp.*	Mycorrhizal fungi	Southwestern United States, Mexico
Misteltoe Cactus	*Austrocylindropuntiavestita*	Cacti	Baja California, Mexico
Epiphytic Hemi-parasitic Plants			
Common Name	**Scientific Name**	**Host Plant(s)**	**Habitat**
Mistletoe Cactus	*Rhipsalis spp.*	Trees and shrubs	Tropical and subtropical regions
Mistletoe Fig	*Ficus spp.*	Trees and shrubs	Tropical and subtropical regions
Mistletoe Fern	*Dendroconche spp.*	Trees and shrubs	Tropical and subtropical regions
Mistletoe Bolete	*Armillariamellea*	Trees and shrubs	Worldwide, diverse habitats
Loranthaceae Family Parasitic Plants			
Common Name	**Scientific Name**	**Host Plant(s)**	**Habitat**
Dusky Coralroot	*Omphorhiza species*	Mycorrhizal fungi	North America, parts of Europe
Showy Indian Paintbrush	*Castilleja spp.*	Various plants	North and South America
Leafy Mistletoe	*Peraxilla spp.*	Southern beech trees	New Zealand

Orchidaceae Family Parasitic Plants			
Common Name	**Scientific Name**	**Host Plant(s)**	**Habitat**
Phantom Orchid	*Cephalantheraaustiniae*	Mycorrhizal fungi	North America, Western Europe
Bird's-nest Orchid	*Neottianidus-avis*	Mycorrhizal fungi	Temperate regions, Northern Hemisphere
Coralroot Orchid	*Corallorhiza spp.*	Mycorrhizal fungi	North America, Europe, Asia
Western Underground Orchid	*Rhizanthellagardneri*	Mycorrhizal fungi	Western Australia
Vanilla Orchid	*Vanilla planifolia*	Trees and shrubs	Tropical regions, widely cultivated for vanilla

transferred cells are some of the potential transfer mechanisms (Estabrook and Yoder, 1998). Hemiparasites, such as Sandalwood, typically feed on the xylem of its hosts (Hibberd and Jeschke, 2001).).**Abiotic stresses in parasitic plants**(Adapted from Zagorchev et al., 2021)

While parasitic plants have adapted to thrive in their parasitic lifestyle, they still face various environmental challenges, including abiotic stresses. Abiotic stresses are non-living factors in the environment that can negatively impact plant growth and development. Some common abiotic stresses include:

Water stress

Parasitic plants, like their hosts, can be affected by drought conditions. However, their parasitic lifestyle may provide some advantage, as they can draw water from the host plant's vascular system during periods of limited water availability.

Temperature stress

Extreme temperatures, either too hot or too cold, can affect the growth and development of parasitic plants. They may be influenced by the thermal environment of both the host and their surrounding habitat.

Nutrient limitation

Although parasitic plants derive some nutrients from their host, they may still face nutrient limitations. Certain abiotic factors can affect nutrient availability in the host plant and, consequently, the parasite.

Light intensity

Parasitic plants often grow in shaded environments, under the canopy of their host plants. Changes in light intensity can impact their photosynthetic rates and overall growth.

Salinity

Some parasitic plants may encounter saline conditions in their habitat, which can affect water uptake and nutrient absorption.

To cope with these abiotic stresses, parasitic plants have evolved various adaptive mechanisms:

Host selection

Some parasitic plants are selective about their hosts, choosing those that grow in environments more favorable to their own survival.

Water use efficiency

Parasitic plants may have evolved adaptations to use water more efficiently or to store water during periods of abundance for use during drought.

Nutrient uptake and transport

Parasitic plants have developed specialized haustoria that facilitate the transfer of water and nutrients from the host plant. They may also have adaptations to acquire specific nutrients more effectively.

Symbiotic relationships

Some parasitic plants form symbiotic relationships with mycorrhizal fungi, which can enhance nutrient uptake, especially phosphorus, from the soil.

Morphological and physiological adaptations

Parasitic plants may exhibit specific morphological and physiological adaptations to tolerate different abiotic stresses. For example, changes in leaf shape, size, and thickness can help them cope with light and temperature variations.

Conclusion

The future of research on parasitic plants looks promising, with potential advancements in genomics, ecology, biotechnology, and conservation. Understanding the ecological roles and adaptations of parasitic plants will not only deepen our understanding of ecosystems but also lead to practical applications for agriculture, medicine, and conservation, making these studies both scientifically and societally relevant.

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Status of NTFP and it's role in livelihood in Chhattisgarh

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Introduction

Non timber forest products constitute an important source of livelihood for millions of people from forest fringe communities across the world. In India, NTFP are associated with socio-economic and cultural life of forest dependent communities inhabiting in wide ecological and geo-climatic conditions throughout the country. It is estimated that 275 million poor rural people in India, depend on NTFPs for at least part of their subsistence and cash livelihoods. Furthermore, the NTFP extraction has multiplier effects in theeconomy by generating employment and income in downstream processing and trading activities. However, depletion of NTFPs resources on account of indiscriminate exploitation, deforestation and forest degradation have a major issue of concern that may affect the NTFP based livelihood and economics.The Term Non timber forest products cover all forest products other than the 'Major Forest products' which consist of timber, small wood, and fuel wood. NTFP, specifically include grass, fruit, leaves bark, animals and mineral products found in forest and collected therefrom.

Keywords: NTFP, Employment, livelihood, forest fringe communities

Status of NTFP in world

Country	Forest area under community (ha)	Annual sales from enterprises	Members of CBNES	Villages supported
Cambodia	51,427	€55189.73	2,558	26
India	17,050	-		211
Indonesia	-	€14,062	27	17
Philippines	572,297.93	€106,673	-	34
Vietnam	140	€65,394.00	-	120

Source: NTFP Annual report 2020-21

Status of NTFP in Chhattisgarh

Chhattisgarh having about 44% geographical area under forest cover, which is very rich in biodiversity because of favorable Agro-climatic conditions.

S.no	Forest type	Area (sq.km)	% of G. Area	Biodiversity status
1	Mixed forests	34230	25.32	Very rich
2	Sal forests	19682	14.56	Rich
3	Teak Forests	5858	4.33	Fairly rich
	Total	59772	44.21	

Source: https://www.cgmfpfed.org

Trade Volume of MFP in Chhattisgarh

Sl. No	category	Species/produce	Estimated trade in Rs. crore
1	Specified	Tendu leaves (*Diospyros melanoxylon*)	1000
2	Non specified	Sal seed (*Shorea robusta*) Harra (*Terminalia chebula*) Gums-kullu (*Sterculia urens*) Bahera (*Terminalia belarica*) Imli (*Tamarindus indica*) Mahua (*Madhuca latifolia*) Lac (*karria lacca*) Mahul leaves (*Bauhinia vahlii*) Chironjee (*Buchananialanzan*)	750
		Total	1750

Source: https://www.cgmfpfed.org

Details of collection and sale of MFP in Chhattisgarh

Product &Year	Collected quantity	Collection wages (Rs.cr)	Sale value (Rs. cr)	Ave. sale rate
Tendu leaves (2021)	13.06	522.20	771.32	6626 per bag
Kullu gum Khair/babul/dhawdagum (2016-17)	4.00 27.500	0.537 0.798	0.064 0.825	1599 3000
Sal seed (2018)	0.012	0.16	0.09	711 per quintal
Harra (2019-20)	33346.360	50.20 lkhs	46.44 lkhs	1836 per quintal

Ave. Annual income per host tree from lac cultivation

Palash = Rs. 900 to 1000

Ber = Rs. 1200 to 1500

Kusum = Rs. 8000 to 10000

Source: https://www.cgmfpfed.org

Livelihood options

Major livelihood options are Lac cultivation, Mahul leaf processing, Tamarind Processing, Aonla Processing, Chironjee processing, Honey production.

Nameof NTFPs	Quantity collected (Kg.)	Cost of collection	Employment days involved in collection of NTFPs	Wage rate	Selling price of NTFPs (Rs. /Kg.)	Income generated through NTFPs
Mahua flower	277.90	3172.5	21.15	150.00	30.82	8564.88
Mahua Seed	100.79	1965	13.10	150.00	26.25	2645.74
Tamarind	113.89	1125	7.50	150.00	31.63	3602.34
Chironji Seed	22.20	952.50	6.35	150.00	124.65	2767.37
Aonla	24.60	600 (4.82)	4.00	150.00	43.47	1069.36

Source: Churpal, 2020

Role of NTFP in livelihood

It is estimated that 275 million poor rural people in India, depend on NTFPs for at least part of their subsistence and cash livelihoods. In India, NTFP are associated with socio-economic and cultural life of forest dependent communities.High economy value through NTFP's. Large scale employment opportunities to the forest fringe people.Provides products for food, shelter, medicines, fibres and energy.In many cultures, livestock provides dietary and living staples (milk, meat, leather, fur, hair, horns, and manure) collecting these non-edible NTFPs can be central to rural development.

Issues in NTFP management

- Unsustainable harvesting (declining of resources)
- Lack of transportation facilities
- Fluctuating and lower prices
- Old production technologies and methods
- Commercialization in production of NTFPs
- Non availability of good market
- No proper research
- Destroy the natural habitats by private markets

Conclusion

The important role of NTFP in rural livelihoods recognize the significant opportunities for achieving both conservation and poverty reduction objectives by supporting the sustainable development of NTFPs**.** Rural people's doing NTFPs value addition, while this process those NTFPs quality will improve simultaneously rural livelihood also improving, but they should know and rectify the negative impact on environment.Develop and support integrated efforts to achieve food security, increase cash income, and conserve forests through NTFP related activities.

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Tree and plants species for pollution management: A comprehensive review

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Abstract

Pollution management is a pressing global concern with significant environmental and human health implications. Due to anthropogenic activity on a worldwide scale, large quantities of particulate matter (PM) and heavy metals are collected in the air, water, and soil. Heavy metals (including cadmium, copper, lead, chromium, zinc, and nickel) accumulate up as a result of industrial processes such mining, smelting, refining, manufacturing, and excessive fertiliser uses in farmers' field. Among the various strategies employed to mitigate pollution, the use of tree species has gained attention due to their potential to absorb and remove pollutants from the air, soil, and water. By accumulating hazardous compounds, plants are a vital part of the environment's cleaning process.An efficient and widely accepted method for reducing pollutants and improving the environment is to plant trees and plants. For bioremediation of urban environmental pollution, careful planning and planting should be done. Depending on the amount and kind of pollution, it is important to choose pollution-tolerant and dust-scavenging trees and bushes.One such mitigation strategy is agroforestry (the common production of both plants and trees), avenue planting, vertical garden, and urban greening etc.The paper highlights the importance of selecting suitable tree species based on specific pollutant types and environmental conditions. Overall, this review contributes to the understanding of the role of tree species in pollution management and provides valuable insights for policymakers, researchers, and practitioners.

Keyword: APTI, Climate change, Mitigation, Pollution, Urban greening.

Introduction

Pollution is the most serious worldwide issue.With the rapid expansion in urbanisation, industrialization, and population growth over the past few decades, there has been a sharp increase in the pollutants of the air, water and soil pollution (Kirthika and Vishnuprasad, 2021). Urban landscapes that are sustainable and healthful are becoming more crucial for human well-being, including human health, ecosystems, climate, and visibility (Chen et al. 2019),is now a days one of the main atmospheric pollution problems, and it is getting worse due to urban population growth, rising traffic density, and industry (Gulia et al. 2015). Pollution management is a critical global challenge that demands effective and sustainable solutions. Among the various strategies employed to combat pollution, the utilization of tree species has emerged as a promising approach due to their inherent ability to absorb and remove

pollutants from the environment. Trees play a crucial role in mitigating different types of pollution, including air pollution, soil contamination, and water pollution.Using some of the green plants to eliminate environmentally hazardous elements is known as phytoremediation, which is an ecologically beneficial and environment cleanup approach. In order to transfer and stabilise contaminants like pesticides, metals, and chlorinated hydrocarbons, it is one of the most affordable, simple, and environmentally friendly methods available (Randive and Jagtap, 2019).

Air pollution and its mitigation

The health of the environment can be measured by plants as bioindicators (Salih et al. 2017).Gaseous pollutants such as sulphur dioxide (SO2), carbon monoxide (CO), nitrogen oxides (NOX), ozone (O_3), lead (Pb), and particulate matter ($PM_{2.5}$ and PM_{10}) are examples of anthropogenic or natural pollutants found in the atmosphere. These pollutants are referred to as the criterion pollutant (Enitin at al. 2022).Precipitation, wind, particulate matter concentration and size of PM have an impact on how much particulate matter (PM) is deposited in the air (Pepek et al. 2019). In Delhi, Mumbai, and Kolkata, respectively, vehicular pollution makes up up to 70%, 52%, and 30% of all air pollution (Karthika and Vishnuprads, 2021).The term "green belt" refers to the widespread planting of pollutant-tolerant trees for the purpose of reducing air pollution by filtering, intercepting, and absorbing pollutants in a sustainable manner (Prajapati and Tripathi, 2008; Isaifan and Baldauf, 2021).The biochemical, physiological, and morphological characteristics of a plant determine its tolerance to air pollution (Singh and Verma, 2007).The ability of leaves to act as dust detectors is influenced by their surface geometry, phyllotaxy, epidermal and cuticular characteristics, leaf pubescence, and tree height and canopy (Nithya et al. 2017).Chen et al (2017) reported that the ability to trap $PM_{2.5}$ was highest in acicular (needle-shaped) leaves, followed by lanceolate leaves.The ability of plants to withstand air pollution is described by the air pollution tolerance index (APTI).It is one of the crucial factors that might be considered while choosing the species of plants for traffic barriers (Shrestha et al. 2021). Four biochemical factors have been used to describe plant APTI: total chlorophyll, relative water content (RWC), ascorbic acid, and pH of leaf extract (Nadgórska et al. 2017). The table 1 shows the APTI value of different tree species.

Formula for APTI estimation:

$$APTI=\frac{[A+(T+P)+(R)}{10}$$

Where, A= Ascorbic acid (mg g^{-1}), T=Total chlorophyll content (mg g^{-1}), P= pH of leaf extract, R= Relative water content (%)

Yang et al. (2015) found that the use of species with high $PM_{2.5}$ removal efficiency, particularly conifer species, has a significant deal of potential to improve the removal of $PM_{2.5}$from urbanair. Similarly, Kirthika and vishnupradas, (2021) reported that the Air Pollution Tolerance Index (APTI) values of plants are in decreasing order as follows: *P. roxburghii, P. pterocarpum, D. regia, P. longifolia, and A. scholaris* can be employed as bio-indicators of air pollution

and in its mitigation for the creation of green belts in urban areas.

Table 1. List of trees with APTI value

S. N.	Botanical name of tree species	APTI value	References
1.	*Peltophorum Pterocarpum, Albezia Lebbeck, Saracaasoca, Spathodia, Campunalata, Michelia champaka, Muntingia calabura, Cassia siamea, Pongamia pinnata, Delonix regia, Anacardium occidentale.*	12.85, 7.83, 16.56, 12.91, 10.76, 6.0, 11.65, 9.39, 7.39, 17.56	Kumar et al. 2018
2.	*Albizzia lebbeck, Cassia fistula, Zizyphus jujuuba, Azadirachta indica, Ficus religiosa, Psidium guajava, Phyllanthus emblica, Tamaridus indica, Moringa olifera Delaonix regia, Tectona grandis, Morus alba*	32, 28, 25, 22, 20, 18, 14, 14, 12, 7, 6, 5	Kumar et al. 2013
3.	*Syzygiumcumini, Micheliachampaca, Acacia melanoxylon Euculeptus sp., Ficus benghalensis, Delonix regia Raf., Morinda pubescens, Millingtonia hortensis, Leucaena leucocephala, Saraca indica, Caesalpinia pulcherrima, Dalbergia lanceolariaL.f., Ficus religiosa, Azadirachta indica, Pongamia pinnata (L.), Madhuca latifolia Roxb, Diploknem abutyrace*	38, 32.6, 28.5, 24.2, 16.8, 14.5, 29.5, 15.6, 18.9, 14.7, 16.4, 32.5, 18.5, 35.6, 32.4, 34.6, 32.4	Begum et al. 2010
4.	*Acacia auriculiformis, Chrysophyllum albidum, Araucaria heterophylla, Mangifera indica L., Elaeisguineensis Jacq. Syzygiummalaccense*	10.7, 10.4, 10.2, 8.03, 7.90, 4.79	Anake et al. 2019

Soil pollution and its mitigation

The functioning of ecosystems is adversely affected by soil contamination, which also poses threats to the environment and human health (Delerue et al. 2022). Soil pollution occurs due to various industrial and anthropogenic activities by which heavy metals/metalloids come from both natural and man-made sources, including the use of phosphate fertilisers in agriculture, sewage sludge, metal mining and smelting, the use of pesticides, electroplating, and the combustion of fossil fuels (Yan et al. 2020).Trees play a significant role in mitigating soil pollution through various mechanisms. They can absorb and accumulate pollutants, enhance soil microbial activity, and promote the breakdown and degradation of contaminants.In order to reduce soil erosion and stop the spread of pollutants to surrounding areas, tree roots help to bind soil particles together.Trees enhance the organic matter content, nutrient cycling, and water-holding capacity of the soil, which helps with soil restoration. Planting trees to restore contaminated soils can encourage the restoration of ecosystem services and functions. The avoidance and tolerance are two defence mechanisms used by plants to combat the toxicity of heavy metals (Yan et al. 2020).Plants

initially attempt to immobilise heavy metals through root sorption or by altering metal ions when they are exposed to them. In the rhizosphere, a range of root exudates, including organic acids and amino acids, serve as a heavy metal ligand to create stable heavy metal complexes(Dalvi and Bhalerao, 2013).Trees can reduce soil pollution through a variety of methods, including phytoremediation (degradation of pollutants by metabolic mechanisms) Labe and Agera, 2017,phytostabilization (use of plant root to limit contaminant mobility and bioavailability in the soil) Jadia and Fulekar,2009,photovolatilization (Plants change pollutants into less digestible forms), rhizodegradatio (degradation via microbialaction in the rhizosphere) (Labe and Agera, 2017; Yan et al. 2020). The example of some tree which is play significant role to mitigate the soil pollution is shown in table 2.

S. No.	Name of species	Heavy metals	References
1.	*Salix viminalis, Poplar* spp.,	Cd, Zn, Pb, and As	Hammer et al. 2003
2.	(*Populus deltoides x maximowiczii*-clone *Eridano and P. x euramericana*-clone	Zn, Cu, Cr and Cd	Sebastiani et al. 2004
3.	*Sasaella glabra, Sasa fortunei Sasa auricoma, Shibataealanceifolia*	pb	Cai et al. 2021

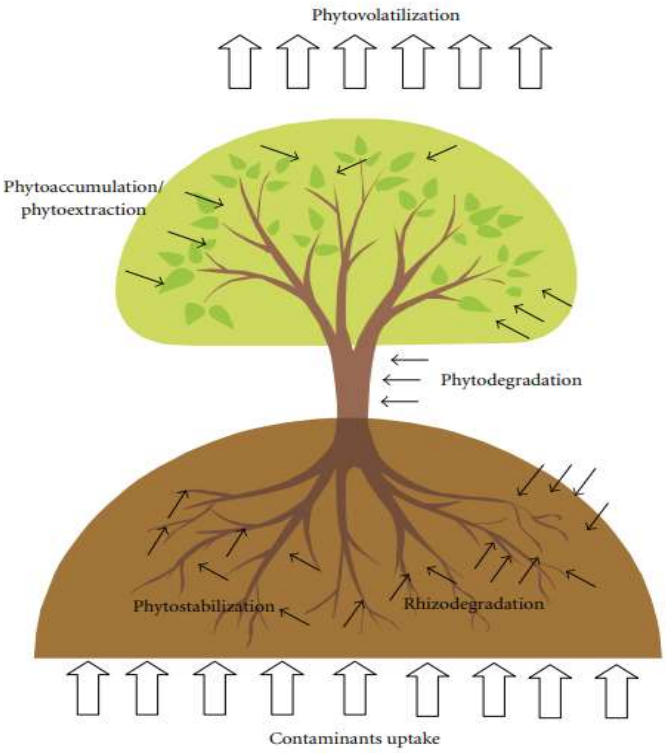

Fig: 1. The mechanisms of phytoremediation technique for heavy metal uptake by plants (Tangahu et al. 2011).

Water pollution and mitigation

Water shortage is an issue for about 40% of the world's population because of climate change, rising urbanisation, food demand, and unrestrained use of natural resources (Calzadilla et al. 2011).Rapid urbanisation, industrialisation, agricultural development, and the release of geothermal fluids and olive wastewater, particularly in places where olives are grown, increased the amount of toxic wastewater (Aguilar, 2009) such as heavy metals (HMs), oils, colours, phenol, cyanides, hazardous organic compounds, phosphorus, and suspended particles are all present in untreated industrial and domestic wastewater released into the environment(Rahman, and Hasegawa, 2011; Pakdel et al. 2018).Trees play a crucial role in mitigating water pollution through various mechanisms such as filtration, absorption, and biological processes. They can intercept and filter pollutants, stabilize riverbanks, and enhance water quality.In phytoremediation, plants collect pollutants through their roots and then move them to their aboveground parts of the body (Sharma et al. 2015).Aquatic plants serve as a natural absorber for pollutants and heavy metals (Pratas et al. 2014).The movement of water and pollutants via a vegetative filter strip can be a challenging procedure since it functionally consists of three distinct layers: the surface vegetation, the root zone, and the subsoil horizon. The efficiency of vegetative filter strips is influenced by field factors like soil type, rainfall frequency, slope, microtopography (surface soil roughness), infiltration capacity of the vegetated region, width of the strip, and height of the plants(Kumar et al. 2013).Pedescoll et al. (2015) found that the two rooted macrophytes *Typha angustifolia* and *Phragmites australis* removed 14–85% of heavy metals from municipal wastewater, including zinc, lead, arsenic, nickel, iron, copper, aluminium, and magnesium.Manjunath and Kousar (2016) studied that *pistia stratiotes*, *azolla pinnata*, and *salvinia molesta* are aquatic plants that have been proven to be particularly effective at removing Fe, Cu, and Mn from textile effluents at a concentration of 25%.

Table 3. List of plant and trees for water treatment

S. No.	Name of plant	Heavy metals	References
1.	*Calendula officinalis L.*	Cd and Pb	Tabrizi et al. 2015
2.	*Calendula alata Rech. fil.*	Cs and Pb	Borghei et al. 2011
3.	*Acacia nilotica, Acacia moniliformis Andrographis paniculate, Ageratum conyzoides, Barleria terminalis, Celosia argentea, Calotropis gigantean*	Cd Cr Ni Zn Pb and Cu	Randive and Jagtap, 2019
4.	*Hydrilla verticillate, Spirodelapolyrrhiza, Bacopa monnierii, Phragmites karka,Scirpuslacustris, Azolla pinnata*	Pb, Cu, Cd, Fe, hg and chromium	Kumar et al. 2013

5.	Duckweed (Spirodelapolyrhiza L	Arsenate and dimethylarsinic acid	Rahman et al. 2008

Conclusion

Large amounts of gaseous and particulate matter are removed from the atmosphere by the many tree species, acting as biological filters.Many of the suggested plants are keystone species that are essential to the growth and upkeep of the ecosystem.Urban trees have a big impact on environmental issues including air quality.The development of a green belt is aided by the planting of trees, which is seen as an effective approach for climate change adaptation and mitigation. Native tree species with specific ecosystem functions are chosen, and locations are deliberately chosen based on the advantages to human health and the environment.For the restoration of soil contaminated by toxic heavy metals, the use of trees as a plant cover appears to be significantly more successful.For the restoration of soil contaminated by toxic heavy metals, the use of trees as a plant cover appears to have significantly greater impact.

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Kigelia pinnata-Medicinal cum avenue tree: suitable for bund planting in riverbanks

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Abstract

Riverbank is a potential site for recreation and same time it is associated with riverbank soil erosion pressure, finally it leads threat to nearby uplands. Riverbanks areas are very suitable raising buffer /dust filters/ carbon sink vegetation which are designed combinations of trees, shrubs, grasses, forbs and bioengineered structures adjacent to, or within, a channel designed to mitigate the impact of soil erosion problems and provide wide ecosystem service functions. While, riverbank stream flow can be effectively streamlined by suitable fast growing buffer vegetation for silt deposition and river bank stabilization uses deep rooted trees. Thus, *K.pinnata* commonly adopted / as an avenue tree both for its beautiful deep red flowers and its strange fruit. The blood-red flowers of the sausage tree bloom at night on long, rope like stalks that hang down from the limbs of this tropical tree. The fragrant, nectar-rich blossoms are pollinated by bats, insects and sunbirds in their native habitat. Recent days, *Kigelliapinnata* is being fetched international important and marketing interest due to many valuable secondary metabolites / compounds. It is fruit extract used as a main ingredient in many pharmaceutical and casmoceutical products include i) anti-melonoma, ii) anti-inflamatory agent, iii) anti-oxidant agent and iv) skin tightening products. In India, there is a lot scope for adopting or cultivating this potential medicinal cum avenue tree for obtaining several economic and environmental benefits through green and clean riverbank region.

Keywords: Avenue tree, Riverbank, buffer vegetation, fruit extract, Skin diseases

Introduction

Kigeliapinnata (Jacq) Dc. belong to the member of *Bignoniaceae* family and it is native to African countries. It is a reasonably large tree, attaining 20m in height and grows in moist places, such as river banks. Its habitat includes open woodlands and moist places such as riverbanks on alluvial soils. With its fast growth rate, spreading canopy, and interesting flowers and fruit. The tree also produces good quality timber and the wood is reported as easy to work with machines for craft work. It is also distributed all over India and abundantly found in west Bengal as ornamental and road side avenue tree. The adult sausage tree has spectacular fruits; these can weigh several kilograms and resemble large

sausages, hence It is known as the cucumber or sausage tree because of huge fruits (Average of 50-60 cm length and 4 kg in weight) which hanges from long fibrous stalks. It is also known as Balmkhira in Hindi and distributed all over India but abundantly found in west Bengal. It is mostly found in wetter areas and spread abundantly across savannah and riverine area (Saini et al., 2009). Unfortunately, even such a "delicious" name doesn't make this fruits edible. Seeds however can be eaten only if roasted. Raw seeds are poisonous.

Description and distribution

In India, the family is distributed in 15 genera and 40 species, including *Kigeliapinnata* which mostly occur in Western and Southern India and a few species in the Himalayas.

Scientific Name

Kigeliapinnata

Common name

Sausage Tree, Common Sausage Tree

Tamil

Sivakundalam, Marasurai,

Hindi

BalamKhira

Botanical name

Kigeliaafricana

Family

Bignoniaceae (Jacaranda family)

Synonyms

Crescentia pinnata, Kigeliapinnata

A tree widespread in African and Asian countries, it is found primarily in woodland spreading into gallery woodland and along rivers in moist forests. In open woodland and in riverine fringes, it occurs at low altitudes. It is widely grown in the tropics and is cultivated in many parts of India but found abundantly in West Bengal as an ornamental and roadside avenue tree. The tree grows to 20 metres or more and is semi-deciduous with smooth grey-brown bark and velvety maroon flowers (Photo.1). The plant grows approximately 10-15 m high with odd pinnately, composite opposite leaves; leaflets are ovate to oblong in shape and 4-18 cm long. The flower are found in spring or summer season, hanging ancillary pendulous panicles up to 2 to 5m long, corolla of fused petals, irregularly bell shaped, 9-13 cm long two lipped, yellowish on outside and purple on inside. Fruits are oblong, hard 30-50 cm long, hanging on strong fibrous stalk for several months but not split easily. The unusual grey, sausage-shaped fruit that give the tree its common name (the sausage tree) hang from rope-like fibrous stalks. They can reach over a metre in length and weigh as much as 10 - 12 kg. The fruit skin is firm, hard and fibrous fruit pulp and contains as many small seeds.

Kigelia begin to flower from the age of 6 years. *K. pinnata* is pollinated by bats, but insects are also attracted to the flowers' colour and fragrance. The tree commonly flowers in the month of August to October and fruiting start from December to June. Depending on the climate, the sausage tree is remarkably fast-growing and can mature in 4 to 5years. Ripe fruits can weigh up to 12 kg and can cause considerable damage when they drop. A mature 10 - 15 year old tree may produce fruits an average of 50-60 fruits per tree with average weight of 4-5 kg per fruit. Approximately 250-300 kg of fruit can be harvested per tree. Mature fruits can be found on trees year-round,

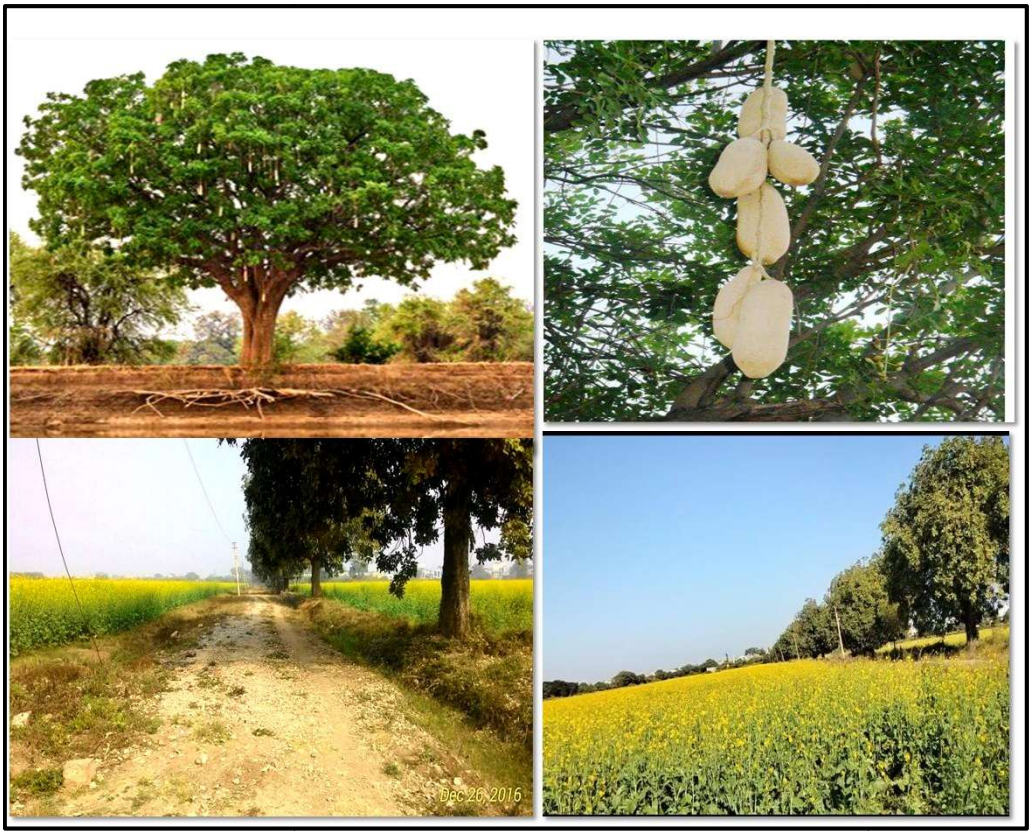

Photo.1: Overview of *Kigeliapinnata*-Medicinal, avenue tree and agroforestry tree

but fruit collected from the ground is often of poor quality as it is quickly infested with insects or consumed by animals. Fresh fruit from the trees are used to produce dried fruit pulp which has a wide range of traditional applications. The fruit skin is firm, hard and fibrous fruit pulp and contains lot of tiny seeds.Seed germination improves after one year of storage, which could be due to physiological dormancy or simply because the fruits are shed before the seeds are fully mature and continue their development on the ground naturally. Soaking the seeds in boiling water for a minute aids germination rate about 80% success rate has been noted. Cuttings can also be used for propagation. Mature stems cut from the tree can be planted directly into soil and root readily.

K.pinnata more preferable semi-deciduous or semi-evergreen tree and commonly adopted / as a high valued ornamental or avenue tree both for its beautiful deep red flowers and its strange fruit in roadside in high ways. The blood-red flowers of the sausage tree bloom at night on long, rope like stalks that hang down from the limbs of this tropical tree. The fragrant, nectar-rich blossoms are pollinated by bats, insects and sunbirds in their native habitat. The mature fruits dangle from the long stalks like giant sausages (Photo1 & 2). They may be up to two feet long and weigh up to 6.8 kg. The flowers are seen hanging from the tree while they haven't opened. After they open, they fall off quite soon. The fruit, while not palatable for humans, is popular with wild animals.

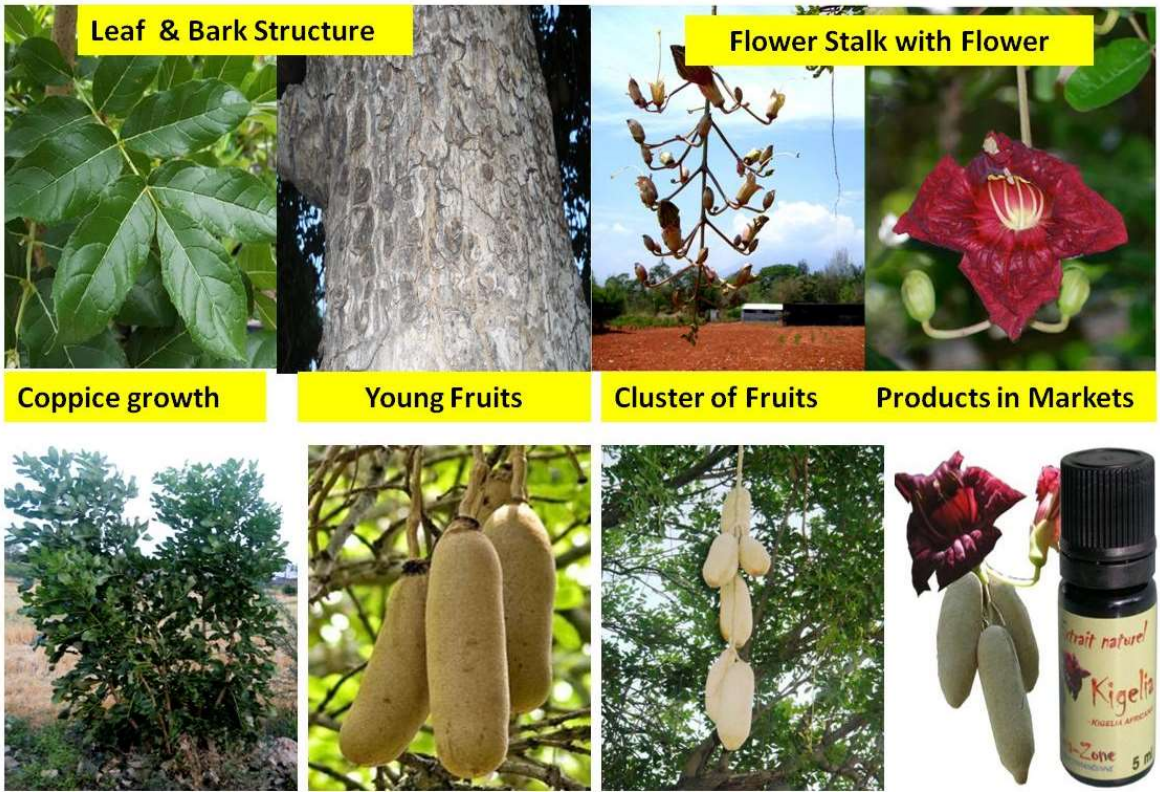

Photo 2: Close-View of *Kigeliapinnata* and Tree Products in Market

***Few image adopted from websource**

The tree's bark is grey and smooth and flakes in older specimens. Leaves are crowded near the tips of branches, and young leaves are brownish red. Flowers bloom in long, loose, pendulous sprays of 5-12 flowers. Petals are a deep, velvety red with yellow veining on the outside. The cylindrical fruit is pendulous on a long fruit stalk. The fruit can grow up to 1 meter long and 20 cm wide and is grey and rounded at the apex (Photo.2). The tree mainly flowers from August to October and fruits from December to June. Depending on the climate, the sausage tree is remarkably fast-growing and can mature in 4 to 5 years. Ripe fruits can weigh up to 12 kg and can cause considerable damage when they drop. With its fast growth rate, spreading canopy, and interesting flowers and fruit, ***Kigelia*** is a popular street tree in South-Asian countries and is grown to provide shade in Australia. It can also be used successfully for bonsai; the thick stem makes for an attractive feature.

Fruiting, harvesting and propagation

Kigelia begin to flower from the age of 6 years. Mature fruits can be found on trees year-round, but fruit collected from the ground is often of poor quality as it is quickly infested with insects or consumed by animals and therefore not used by humans. Fresh fruit from the trees are used to produce dried fruit pulp which has a range of applications. Seed germination improves after 1 year of storage, which could be due to physiological dormancy or simply because the fruits are shed before the seeds are fully mature and continue their development on the ground naturally. Soaking the seeds in boiling water for 1 minute aids germination and 80% success rate has been noted. Cuttings can also be

used for propagation. Truncheons cut from the tree can be planted directly into soil and root readily. ***Kigeliapinnata*** is pollinated by bats, but insects are also attracted to the flowers' colour and fragrance. These benefits the ***Kigelia*** trees because it prevents large losses of the higher diameter fruit, as harvesting from flooded plains can become difficult. This flooding rescues trees from damage by herbivores (***e.g.***, baboons, elephants) and allows for regeneration.

Traditional uses

Kigeliapinnata has a long history of use by rural tribes, but very little had been documented. Traditional African healers use the sausage tree to treat a wide range of skin problems, from fungal infections, boils, psoriasis and eczema, to the more serious diseases, such as leprosy, syphilis and skin cancer. These properties are found in every part of the tree, including fruit, bark, roots and leaves, which are employed for medical purposes. The Kigelia plant have medicinal properties not only because of its perceived characteristics such as bitterness, astringent taste or smell but also because of forces that it seems to emit in connection with its location, orientation and association with other plants.The plant possesses traditional uses like anticancer, antiulcer, anti-aging, antioxidant, and anti malarial. It is also widely applied in the treatment of genital infections, gynaecological disorders, renal ailments, fainting, epilepsy, rheumatism, sickle-cell anemia, psoriasis, eczema, central nervous system depression, respiratory ailments, skin complaint, body weakness, leprosy, worm infestation and tumours etc. Fodder: When the flowers and leaves fall to the ground they are eaten by game and livestock. Apiculture: The large, maroon flowers attract bees and are a source of bee forage. Timber: Wood is moderately heavy (air-dry 720 kg/cubic m). The wood is easy to work and produces a good-quality timber for general use. The sapwood is whitish or yellow and, although rather soft, has been used for planking, yokes, fruit boxes and shelving. Heartwood is light brown and is used for drums, utensils and cutlery. In South Africa, inhabitants of the areas along larger rivers, especially the Chobe and Zambezi, make their dugout canoes from *K. pinnata*. Tannin or dyestuff: A black dye can be produced from the fruit. Tannin can be extracted from the roots and stem bark. Poison: The fruit extract is reported to have molluscicidal properties. Raw fruit are poisonous to humans but edible to wild animals.*K. pinnata* makes a good shade tree, casting dense shade, though it is not advisable to park a vehicle or to put up a tent underneath a sausage tree during the fruiting period. The 'sausages' that drop every so often weigh up to 12 kg and can cause considerable damage. Other benefits like germination stimulator, example fruit pieces soaked in water, together with small pieces of metal are sprinkled with young palm fronds, stimulate the germination of yam tubers as well as promote a good harvest in Nigeria.

African considered this species equivalent to the Indian Neem tree because this indigenously grown *Kigeliapinnata* have immense medicinal potential and it has a long history of use by rural Africans, they were traditionally attached with this species for many centuries. However, last four decades, focus and attention raised

and it is being cultivated throughout sub-saharan Africa, African indigenous people for medicinal and cosmetic applications. One the native African tree with great curative potential is the sausage tree (*Kigeliaafricana; syn. K. pinnata*). Kigelia is now generally considered to be a highly variable monospecific genus of the family Bignoniaceae. The powdered leaves are used for their wound healing and cleansing properties and it is used for sexually transmitted diseases (STDs), malaria and a whole range of diseases including gynaecological ones.

Current focus pharmacy industries in *K.pinnata*

These tree species now fetching international important and marketing interest due to many valuable secondary metabolites / compounds including irridoids, flavonoids, naphthoquinones and other phytoconstituents in different parts of tree. The kigelia plant contains steroidal saponins and two flavonoids (luteolin and quercitin). This is main ingredient in many pharmaceutical and casmoceutical products include-i) anti-melonoma, ii) anti-inflamatory agent, iii)anti-oxidant agent and iv) skin tightening products (Saini, *et al*.,2009). Fruit extract have immense value in pharmaceutical and cosmoceutical preparations like anti-sun turn cream, anti-aging and skin tightening creams. Many cosmetic companies have acknowledged the fruit's skin-enhancing properties through the addition of fruit extract to some of their products. Medical research has also revealed evidence that Kigelia fruit extract may be effective in helping to treat melanoma, the deadliest form of skin cancer (Jackson *et al.,*2000). Traditional African healers use the Sausage tree to treat a wide range of skin problems, from fungal infections, boils, psoriasis and eczema, to the more serious diseases, such as leprosy, syphilis and skin cancer (Houghton, 2002). These properties are found in every part of the tree, including fruit, bark, roots and leaves, which are employed for medical purposes (Grace *et al.,* 2002). Kigelia plant contains steroidal saponins and two flavonoids (luteolin and quercitin). This is main ingredient in many pharmaceutical and cosmoceutical products include i) anti-melonoma, ii) anti-inflamatory agent, iii) anti-oxidant agent and iv) skin tightening products (Saini *et al.,*2009).

In its review of the literature covering kigelia's cosmeceutical applications, the authors of the 2009 "Natural Product Radiance" article reported Kigelia was already widely used as an active ingredient in a variety of cosmetic formulations. These products can give skin a smoother appearance by reducing fine lines and wrinkle depth. They also are believed to promote skin elasticity, naturally lighten pigmentation, reduce blemishes and increase circulation to the skin. Saini et al., (2009) studies that found kigelia's active ingredients include steroidal saponins and the flavonoids luteolin and quercetin. These phytochemicals help strengthen and stabilize the collagen fibers that support the skin, thus having a firming effect. Some studies found that the extract was particularly effective in firming the skin in and around the breasts. Kigelia seems to encourage the growth of collagen. A lack of collage is what leads to wrinkles in old age (Saini et al., 2009).

Researchers in Northern Ireland conducted an in vitro study to assess the ability of various compounds from the *Kigeliapinnata* fruit to halt the spread of human melanoma cells. Part of the impetus for the study was the traditional use of the fruit by folk healers to treat skin cancer and other skin disorders. Scientists isolated several compounds from the kigelia fruit and tested them against melanoma cells in the lab. They found significant anti-cancer properties from a variety of kigelia compounds, including the isocoumarinsdemethylkigelin and kigelin; oleic and heneicosanoic fatty acids; ferulic acid; and the furonaphthoquinone 2-(1-hydroxyethyl) naphtho[2,3-b]furan-4,9-dione. In their findings, published in a 2010 issue of"Planta Medica," researchers noted that the furonaphthoquinone was also effective in vitro against two strains of breast cancer cells.

Researchers then tested the extracts against gram-negative and gram-positive bacteria. In a report on their findings in a 2002 issue of the "South African Journal of Botany," they reported stem bark and fruit extracts showed significant antibacterial activity against both strains of bacteria. A five-member Indian team of scientists undertook a review of the scientific literature covering studies into kigelia's medicinal and cosmeceutical properties. In their report, published in a 2009 issue of "Natural Product Radiance" - known in 2011 as the "Indian Journal of Natural Products and Resources" -- they cited studies that found kigelia's active ingredients include steroidal saponins and the flavonoids luteolin and quercetin. These phytochemicals help strengthen and stabilize the collagen fibers that support the skin, thus having a firming effect. Some studies found that the extract was particularly effective in firming the skin in and around the breasts. Following up on studies that showed the stem bark of the Kigelia possessed potent antibacterial properties, a team of South African researchers conducted a study to see if the kigelia fruit offered those benefits as well. They prepared crude extracts of both stem bark and fruit using distilled water, ethanol or ethyl acetate. These findings have paved the way for the use of kigelia extract in skin-cleansing agents and other products designed to combat bacterial skin infections (Houghton, 2002).

Conclusion

The sausage tree is suitable for riverbank erosion control through its strong network roots and longevity in soil stabilization. By establishing or managing, K.pinnata based multilayer vegetation with erosion resistance shrubs and grasses in the zone adjacent to streams beds, water quality and aquatic ecosystem health can be sustained or enhanced as well as provide involvement cum willingness in management nearby people are willing to follow to keep buffer vegetation healthy and effective. The tree is most common tree in riverbank, floodplains, wet savannah and woodlands.High ornamental value with its fast growth rate, spreading canopy and interesting flowers and fruits, it makes a good street tree and is popular for this purpose in various towns in the countries north of South Africa, India and in Australia. It can be used successfully for bonsai, the thick stem being an attractive feature. The trees are normally found on flatlands which have a high water content (alluvial soils), and are periodically

flooded, riverbank, stream banks thereby often rendering them unsuitable /undulated lands which is unsuitable farming agricultural crops.

Bamboo plantation through advanced method

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Bamboo is one of the fastest growing plants, with the ability to survive in a variety of climatic and soil conditions. At present, the Government of India has removed bamboo from the category of tree to encourage bamboo cultivation so that there is no legal hindrance in harvesting bamboo and it can be easily harvested and sold.

The subfamily Bambusoideae of the grass family Poaceae has a broad array of perennialflowering plants, many of which are evergreen. The largest grass species are giant bamboos, which individual culms of *Dendrocalamusstricus* reaching a length of 46 metres, a thickness of up to 36 centimetres, and a weight of up to 450 kilogrammes.

Most of bamboo species are native to hot, humid tropical areas as well as hot, temperate climes. Additionally, they are found in highland cloud forests and chilly mountainous areas.The majority of bamboo species are native to hot, humid tropical areas as well as hot, temperate climes. Additionally, they are found in highland cloud forests and chilly mountainous areas.There are over 1000 species of bamboo. It is a type of grass and grows from its roots, when it is cut it quickly grows back with most species maturing in 3-5 years. This amazing plant grows in both tropical and temperate environments and is very hardy, not needing pesticides or herbicides to grow well.

The uses of bamboo

Bamboo is an abundant, renewable, and simple to grow resource. Construction, clothing, food, and fuel are just a few of the many uses for this incredibly adaptable material.There are several commercialuses for bamboo, including the production of furniture, toys, agricultural equipment, ladders, baskets, mats, bottles, and cutlery. Paper can also be made with it. Becauseof its numerous uses, bamboo is sometimes known as "green gold".(Source: INBAR 2017)

Suitable species of bamboo

Bamboo is divided into two main categories; Sympodial or clustered and monopodial (runner) non-clustered. Several species of bamboo bunches can be easily planted such as *Bambusa vulgaris, Dendrocalamusstrictus, Bambusatulda, Dendrocalamus asper* etc.

Methods of planting bamboo

Bamboo can be planted in the following traditional and non-traditional ways.

Traditional methods

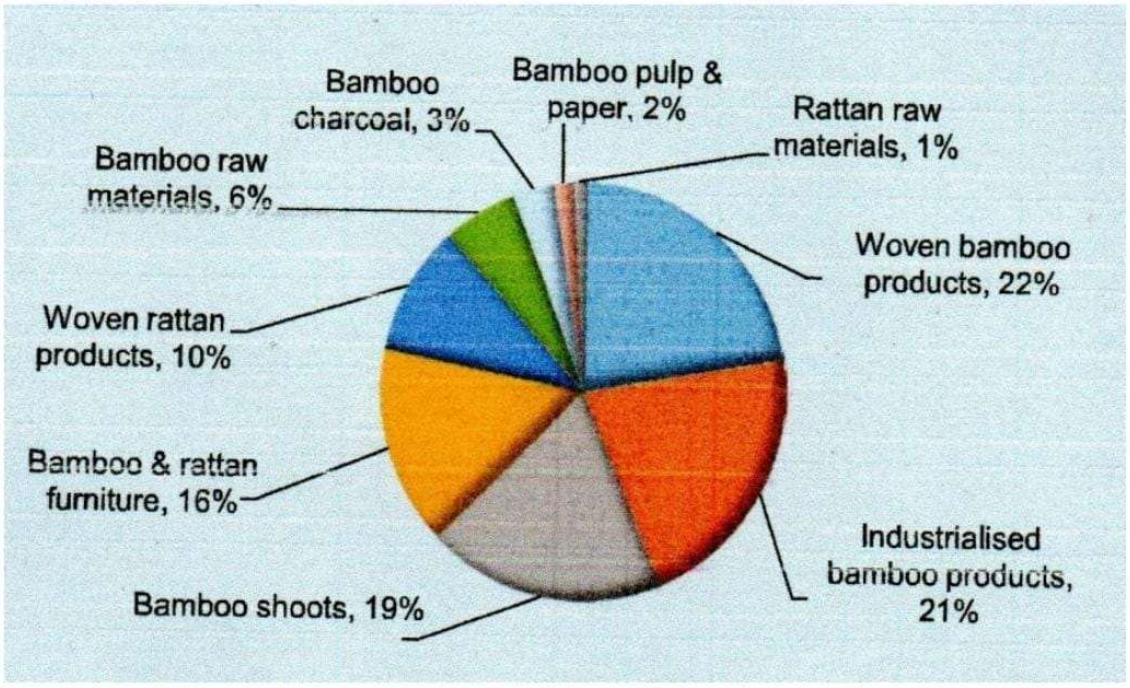
a) Planting by seeds
b) Planting by rhizome and off-set

Non-traditional methods

a) Applying by Stem Cutting
b) Planting by cutting branches
c) Applying by pressure-column
d) By tissue culture.

Planting by seed

The availability of bamboo seeds is limited to a specific period as bamboo flowers only once in a lifetime. Most bamboo flowers fructify at long time intervals of



30-120 years, depending on the species. The capacity of bamboo seeds is for a very short time hence bamboo seeds should be sown within 1 month as soon as possible after collection. Seeds germinate within 5 to 10 days. Transplantation of bamboo by seeds is done in the nursery before the start of rainy season (April-May) and they are allowed to grow in the nursery for one year. Then this seedling should be transplanted to the main field in the monsoon (rainy season).

Vegetative propagation method

Since seeds are not available most of the time, bamboo is being propagated as a sport. Various methods of propagation such as off-set, rhizome, cutting, and pressing are commonly used. Of these, rhizomes or offset seedlings are most commonly used.

Rhizomes and offset method

The rhizome of the 1to 3 year old off-set is dug up along its base and clipped to a height of around 1-1.5 m (3-5 nodes). Before it starts to rain, the rhizomes are cut out and put in the ground so the roots can grow there. The off-set should be implanted as soon as it is removed from the main clump and transported in a wet sack bag. During the extended dry season that occurs in the Bundelkhand region, new plants could need daily irrigation.

Stem and branch cutting method

The stem and branch planting technique for bamboo is the most effective planting technique available. Large-scale bamboo seedling preparation is possible. The following are some bamboo planting methods that involve cutting: -

Preparation of nursery

First, a nursery bed that is 10 metres by 1.5 metres and is prepared with soil, sand, and manure in a 2:1:1 ratio. One week prior to transplantation, aldrin and webastin are mixed in the nursery bed to guard against termites and fungi. Use 40 litres (0.015%) and 30 litres (0.05%) for each carry, respectively.

Stem selection and planting method

The healthy and 2-3 years old stem is cut from the ground surface leaving one / two knots. The upper weak part of the stem, all the extra branches and leaves are pruned. Then cut into 10-16 pieces. In depth, 40-50 cm. Plant in the horizontal direction in the nursery bed at a distance of 2-3 cm above the soil. It is covered with layer. This distance and depth can be increased according to the thickness of the stem.

Treatment of the graft for root planting

The stem is briefly immersed in a solution of boric acid of 200 ppm concentration (200 mg/l of water).

Nursery management – Shadow

The nursery should be used for mulching such as dry grass and straw to conserve moisture and to protect the stem from sunlight which can be removed early in the monsoon.

Fertilizer and irrigation

Stems should be frequently watered in the morning and evening, early in the day before it starts to rain. After the plants have grown, the irrigation interval can be lengthened. Stay away from overwatering and drying. Decompose F. Y. entirely if it is necessary to boost the strength of the shoots in poor soil. It is workable. Only after the new copal has fully emerged from the soil should fertiliser be applied to avoid damaging other new copal that is emerging from the soil at the same time.

Transplanting

It takes approximately a month or two for the roots to form from the stem. Rhizome growth and the emergence of new coppice take three to four months. After roughly 4-6 months, plants are transplanted onto the field between June and July. If the plants need to be carried across long distances, the dug plants can be cut into large sizes (30x30 cm), which can then be transplanted into the polybag. The buds can be carefully separated by cutting them in the middle of the internode.

Layering method

There are two ways of layering, first ground layering second air layering ground layering method. It should be used in April-May.

Tissue culture method

In recent times bamboo is being prepared by tissue culture technique so that flowers come in bamboo in less time and high quality can be maintained.

Different methods of bamboo cultivation

Bamboo can be planted in the fields according to the purpose and according to the size of the land in the following ways-

On the edge of the fields

Bamboo can be planted on 1m wide mat at a distance of 2mx 3 meter or 5m x 4 meter. A maximum of 200 saplings can be planted per acre. To plant bamboo, first we have to dig pits of 30x30 cm at the prescribed distance, in each pit 1.5 kg fertilizer, 100gm urea, 100gm super phosphate and 50gm potash should be mixed with soil.

In the agroforestry system

In this method, bamboo 5 x 5 m. from 10 x10 m can be applied. Intercrops are planted between the two rows along with

bamboo, gram, gum, sesame, urad; moong can be easily taken in the agricultural crops in the agroforestry system. Along with this, other fodder crops can also be successfully selected such as jack bean has been successfully planted in the university with bamboo which is not only used for fodder but its tender legumes are also used as a vegetable, which are also useful in terms of nutrition-security.

Intensive bamboo plantation method

The standard spacing for rows is 1 m by 0.5 m. This void is occasionally changed to accommodate the soil's fertility and the type of bamboo.

Harvest and yield

Bamboo stems are usually ready for harvesting in 6-7 years. Bamboo stems should be harvested by picking from the bunch, starting from the harvesting center as new pens come out. Harvesting of stem should always be done in dry weather. The weight of each stem is considered to be 15-20 kg and one acre of land with 200 bamboo plants can produce about 13.5 tons in the 6th year of planting.

Economic benefit

Bamboo can be grown for 40 years. At least 200 saplings can be planted per acre. In the first year of planting, an average expenditure of Rs. 350 per plant is incurred which includes purchase of plant, fertilizer, drip irrigation facility and labour charges. Which remains 180 rupees per plant next year? From the fifth year, we can cut 3-5 stems per plant, which is 900-1000 per acre, and at about Rs 100 per stem, we can earn Rs 90,000. The profit per acre is 1, 20,000 next year and from the seventh year onwards, the profit becomes 1, 40,000 per acre. Along with

this, farmers can also earn profit by preparing bamboo saplings and selling them directly and increase their income two to three times.

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चंदन की खेती

प्रेम कुमार राना एवं त्रिलोक गुप्ता

भा.वा.अ.शि.प.- उष्णकटिबंधीय वन अनुसंधान संस्थान

जबलपुर (म.प्र.)

चंदन पूरे विश्व में एक बहुमूल्य वृक्ष प्रजाति है।चंदन की मनमोहक खुशबू और इसके औषधीय गुणों के कारण निरन्तर इसकी माँग बढती जा रही है। चंदन की लकड़ी देश में ₹ 8000 से 10000 प्रति किग्रा तो विदेश में ₹ 20000 से 25000 प्रति किग्रा तक बिकती है। सफेद चंदन सदाबहार वृक्ष है इस पेड़ से मिलने वाला तेल और लकड़ी दोनों ही औषधीय गुणों से भरपूर है। इसके अर्क को खानपान में फ्लेवर के तौर पर इस्तेमाल किया जाता है। साबुन, कॉस्मेटिक्स, अगरबत्ती और परफ्यूम में सफेद चंदन के तेल को खुशबू के तौर पर इस्तेमाल किया जाता है। प्राकृतिक रूप से चंदन का विस्तार 30 डिग्री उत्तर से 40 डिग्री दक्षिण तक है पूर्व में इंडोनेशिया से लेकर पश्चिम में चिल्ली और उत्तर में हवाई प्लेनजो से लेकर दक्षिण में न्यूजीलैंड तक पाया जाता है । वैसे तो चंदन का पूरा वृक्ष ही उपयोग में आता है किंतु तने का आंतरिक भाग जिसे हार्टवुड कहते हैं विशेष रूप से व्यापारिक महत्व का होता है क्योंकि इसमें 3% तक तेल होता है। उच्च गुणवत्ता एवं अधिक मूल्य के कारण चंदन का प्राकृतिक वनों से दोहन हो चुका है। पूर्वी भारत से प्राप्त चंदन का तेल उच्च गुणवत्ता, दृढ़ एवं स्थिर खुशबू वाला होता है। परंपरागत रूप से चंदन के वृक्ष का उपयोग विभिन्न उद्देश्यों के लिए किया जाता है इसके विभिन्न अवयवों को इत्र, अगरबत्ती, हस्तशिल्प एवं कई धार्मिक कार्यों में प्रयोग में लाया जाता है ।

होस्ट पौधे के साथ चंदन वृक्ष

चंदन के वृक्ष में हार्डवुड का निर्माण लगभग 15 वर्षों के उपरांत होता है इसके अत्यधिक दोहन और अवैध व्यापार के कारण प्राकृतिक वनों में इसकी उपलब्धता बेहद कम हो गई है । चंदन के अनुवांशिक संरक्षण एवं सतत उपलब्धता हेतु इसकी खेती करने का कार्य शुरू किया जाना आवश्यक है। इस हेतु वर्ष 2001 एवं 2002 में कर्नाटक एवं तमिलनाडु राज्य ने चंदन की खेती को बढ़ाने के उद्देश्य से नीतियों को उदार किया है और कई प्रकार की छूट दी हैं। इन नीतियों के कारण कई किसानों ने अपनी कृषि भूमि पर चंदन की व्यवसायिक खेती आरंभ की है। उच्चतम कीमतों एवं बढ़ती बाजार की मांग के चलते कई

अन्य राज्यों जैसे आंध्र प्रदेश, तेलंगाना, महाराष्ट्र, मध्य प्रदेश, गुजरात, आसाम, पंजाब आदि राज्यों के किसानों ने भी इस व्यवसाय खेती को अपनाया है।

चंदन का वृक्ष

चंदन के वृक्ष हरे रंग के और 8 से 12 मीटर ऊंचे होते हैं। इसकी शाखाएं झुकी होती हैं। चंदन के पेड़ की छाल लाल या भूरे या फिर भूरे, काले रंग की होती है। चंदन के पत्ते अण्डाकार, मुलायम होते हैंएऔर पत्ते के आगे वाला भाग नुकीला होता है। चंदन के फूल भूर, बैंगनी, या जामुनी रंग होते हैं, जो गंधहीन होते हैं। इसके फल गोलाकार, मांसल होते हैं, जो पकने पर श्यामल या बैंगनी रंग के हो जाते हैं। इसके बीज कठोर, अण्डाकार अथवा गोलाकार होते हैं।

चंदन के वृक्ष प्रायः 15 वर्ष के बाद ही बड़े होते हैं। पेड़ के भीतर का हिस्सा हल्का पीला रंग काएऔर सुगंधित होता है। पुराने वृक्षों की छाल दरार युक्त होती है। चंदन का वृक्ष 40-60 वर्ष की आयु के बाद उत्तम सुगन्ध वाला हो जाता है। चंदन के वृक्ष में फूल जून से सितम्बर के बीच होते हैंएऔर फल नवम्बर से फरवरी तक होते हैं। ऐसी अवस्था में चंदन पूरी तरह से उपयोग करने लायक हो जाता है।

चंदन का रोपण एवम प्रबन्धन

किसान अपने खेतों में चंदन का रोपण ब्लॉक या बाड प्लांटेशन के रूप में या कृषि वानिकी प्रणाली जैसे चंदन एवं बागवानी, चंदन एवं कृषि, आदि प्रणाली के रूप में करते हैं। सामान्यतः चंदन रोपण प्रबंधन हेतु निम्नलिखित गतिविधियां सम्मिलित होती हैं।

स्थल चयन, भूमि सुधार, गड्ढा खोदना एवं रोपण,होस्ट प्लांट का प्रबंधन, शाखा की छटाई, सिंचाई, उर्वरक का चयन, खरपतवार हटाना आदि शामिल हैं। चंदन वृक्षारोपण में उसकी सुरक्षा एक महत्वपूर्ण कार्य है।

स्थल का चयन

सामान्यतः भूमि चयन भिन्न-भिन्न स्थानों पर अलग-अलग हो सकता है। व्यवसायिक रोपण हेतु सामान्य यानी न्यूट्रल पीएच 6.5 से 7.5 तक होना चाहिए । भूमि खरपतवार रहित और उसकी ठीक ढंग से जुताई की गई होनी चाहिए। सामान्यतः चंदन के वृक्ष समुद्र सतह से 650 से लेकर 1200 मीटर की ऊंचाई एवं 500 से 1600 एमएम वर्षा वाले स्थानों पर अच्छी वृद्धि करते हैं। चंदन का वृक्ष अधिक प्रकाश की मांग करता है,अतः इसे अधिक छायादार स्थल पर ना लगाएं अधिक वर्षा वाले स्थानों में इसकी वृद्धि तो अच्छी होगी लेकिन हार्डवुड का निर्माण कम होता है और तेल का प्रतिशत भी कम हो जाता है हालांकि चंदन का वृक्ष खराब एवं पथरीली जमीन पर भी अच्छी तरह वृद्धि देता है।

भूमि सुधार

चंदन रोपण के पूर्व जमीन को समतल करने के लिए उसकी अच्छे ढंग से जुताई करना जरूरी है जिससे मिट्टी में उसकी जड़ों को फैलने में आसानी होती है इसके बाद 3 से 4 मीटर की दूरी पर गड्ढों के लिए मार्किंग करनी चाहिए । अच्छी जुताई से जमीन में हवा का आवागमन, पानी की पैठ, खरपतवार का सफाया एवं मृदा में मौजूद कीटों एवं फफूद के बीज धूप में आकर मर जाते हैं यह कार्य मार्च से अप्रैल के बीच कर लेना चाहिए और रोपण का कार्य जून-जुलाई तक करना चाहिए। इसकी खेती सभी तरह की मिटटी में हो सकती है लेकिन रेतीली मिटटी, चिकनी मिटटी, लाल

होस्ट पौधों के साथ चंदन रोपण

मिटटी, काली दानेदार मिट्टी चन्दन के पौधे की लिए ज्यादा उपयुक्त है।

गड्ढों की खुदाई एवं रोपण

निर्धारित दूरी पर मार्किंग किए गए स्थानों पर 45 ग् 45 ग् 45 सेंटीमीटर की गहराई के गड्ढे तैयार किए जाने चाहिए यह डिजाइन इस बात पर भी निर्भर करता है की साथ में लगाए जाने वाला होस्ट प्लांट किस प्रजाति का है। गड्ढों को खुदाई के बाद एक माह तक खुला छोड़ दें जिससे धूप पर्याप्त रूप मिल सके। रोपण के समय प्रत्येक गड्ढे में 2 किलो गोबर खाद डालनी चाहिए, रोपण को तैयार करने के लिए नर्सरी में बीजों की बुवाई कर देनी चाहिए। यह पौधे जब लगभग 1 फिट की लंबाई एवं लगभग 3 मिलीमीटर कॉलर डायमीटर के हो जाएं तब रोपण के लिए उपयुक्त होते हैं। मानसून की शुरुआत में रोपण कार्य शुरू किया जा सकता है।

होस्ट पौधे का चयन

चंदन के लिए सहयोगी होस्ट के चुनाव एवं उसके चंदन के साथ परस्पर संबंधों को लेकर भारत,ऑस्ट्रेलिया, इंडोनेशिया आदि कई देशों में अनुसंधान हुए हैं। फॉक्स एवं ब्रांड ने अपने अध्ययन में पाया कि चंदन की जड़ें 20 मीटर तक फैल कर अपने को होस्ट प्लांट की जड़ों से जुड़ने की क्षमता रखती हैं। यह जड़ें अपने हॉस्टोरिया नामक रचना से दूसरे पौधों की जडों से मिलकर जल एवं खनिज अवशोषण करती हैं। चंदन के वृक्ष को अपने जीवन काल में अलग-अलग समय पर अलग-अलग होस्ट बदलने की आवश्यकता होती है। प्राथमिक होस्ट के तौर पर छोटे एवं आसानी से उगने वाले स्थानीय पौधे प्रजातियों का चयन किया जाता है,जिनमें बहुत अधिक वृद्धि ना हो। एक से 3 वर्षों के उपरांत द्वितीयक होस्ट की आवश्यकता होती है जिनसे चंदन को आवश्यक पोषण प्राप्त होता है द्वितीयक होस्ट 6 से 8 वर्षों तक जीवित रहते हैं। इसके उपरांत तृतीयक होस्ट की आवश्यकता होती है इन होस्ट प्लांट को उनकी आयु के हिसाब से तीन वर्गों में विभाजित किया जा सकता है लघु, मध्यम एवं दीर्घायु। उदाहरण स्वरूप मिर्च, टमाटर, बैंगन,

तुवर दाल इत्यादि। लगभग 30 से 35 वृक्ष प्रजातियों को होस्ट के तौर पर लगाया जा सकता है,जिनमें प्रमुख हैं कैजूरायना, नीम,बकायन,खैर, अर्जुन, शीशम,सागौन, मुंनगा, जामुन, महुआ आदि।

शाखा की ताराशी

चंदन के पौधों या वृक्षों में शाखा तराशी की आवश्यकता नहीं होती समय के साथ साथ उनमें स्वयं शाखा गिर जाती हैं। शाखा की ताराशी से चंदन की छाल को नुकसान पहुंच सकता है जिससे वृक्ष मर भी सकता है या उसके ऊपर किसी कीट या फफूद का प्रकोप भी हो सकता है।

सिंचाई

बारिश के समय में चंदन के पेड़ों का तेजी से विकास होता है लेकिन गर्मी के मौसम में इसकी सिंचाई अधिक करनी होती है। सिंचाई मिट्टी में नमी और मौसम पर निर्भर करती है। शुरुआत में बरसात के बाद दिसंबरसे मई तक सिंचाई करना चाहिए। जिस दिन रोपण का कार्य किया जाए उस दिन भरपूर पानी देकर खेत को तर कर देना चाहिए उसके बाद जब तक पौधे अच्छी तरह से स्थापित ना हो जाएं रोजाना 8 से 10 लीटर पानी प्रत्येक पौधे को देना चाहिए। उसके बाद 3 से 6 महीने तक हर 4 दिन के अंतराल पर पानी देना चाहिए ताकि मिट्टी में नमी बरकरार रहे। चंदन का वृक्ष सूखे के प्रति सहनशील होता है अतः स्थपित होने के बाद इसे ज्यादा मात्रा में पानी की आवश्यकता नहीं होती।

उर्वरक

पहले वर्ष इसे किसी खास उर्वरक की आवश्यकता नहीं होती यदि आने वाले समय में मृदा में किसी खास पोषक तत्व की कमी हो तो उसे उर्वरक दिए जा सकते हैं। मानसून से पहले वर्ष में एक बार 50 से 100 ग्राम तक डीएपी प्रत्येक पौधे को दिया जा सकता है और साथ ही सामान्य स्वाइल वर्किंग भी की जानी चाहिए।

खरपतवार नियंत्रण एवं सुरक्षा

यदि कोई खरपतवार चंदन के पौधे की वृद्धि को प्रभावित करती है तब खरपतवार उन्मूलन करना आवश्यक होता है। इस हेतु किसी रासायनिक दवा का प्रयोग नहीं करना चाहिए।

चंदन के वृक्ष के बड़ा हो जाने पर चोरी के भय से चन्दन वृक्ष की सुरक्षा करना अति आवयशक हो जाता है चंदन की लकड़ी की अवैध तस्करी से चन्दन के पेड़ तेजी से कम हो रहे है चंदन के वृक्षारोपण स्थल की सुरक्षा हेतु तार की बाढ़ लगाना आवश्यक है ताकि इसे चोरी होने से बचाया जा सके।

उत्पादन एवं आय

चंदन के एक एकड भूमी (300 पौधे प्रति एकड) पर रोपण में जिसमें भूमि की तैयारी, पौध, उर्वरक, अन्य खर्च एवं 15 वर्षों तक रखरखाव के खर्च को शामिल कर लिये जाये ंतो इन सब की कुल लागत 11लाख रूपये आती है। सर्वाधिक व्यय इसकी सुरक्षा पर होता है। 14 से 15 साल के बीच यह बिकने के लिए तैयार हो जाता है। चंदन के पेड़ की जड़ से सुगंधित प्रोडक्ट्स बनते हैं। इसलिए पेड़ को काटने के बजाए जड़ से ही उखाड़ा जाता है। उखाड़ने के बाद इसे टुकड़ों में काटा जाता है। एवरेज कंडीशन में एक चंदन के पेड़ से करीब 10 किलो तक अच्छी लकड़ी निकल जाती है। आमतौर पर चंदन की लकड़ी 9500/- रुपए प्रति किलो की दर से बिकती है अगर क्वालिटी अच्छी हो तो 10 हजार रुपए किलो तक दाम आसानी से मिल जाते हैं। काष्ठ विज्ञान एवं प्रौद्योगिकी संस्थान, बैगलुरू द्वारा किये गये एक आकलन के अनुसार 300 वृक्षें ा से कुल 3000 किग्रा लकडी प्राप्त होगी जिसका अनुमानित मूल्य

3000 x 9500= 2,85,00,000/- रूपये होता है, अर्थात प्रति एकड कुल आमदनी 2.74 करोड रूपये हो सकती हे। चन्दन वृक्ष की आयुवृद्धि के साथ ही साथ उसके तनों और जड़ों की लकड़ी में सुगन्धित तेल का अंश (2-3%) भी बढ़ने लगता है। तने की नरम लकड़ी तथा जड़ को जड़ या बुरादा, तथा छिलका बेचा जाता है। प्राचीन आसवन विधि द्वारा चन्दन की लकड़ी से सुगंधित तेल निकाला जाता है भारत में चंदन का तेल सौंदर्य प्रसाधन के रूप में मुंबई,कोलकाता, दिल्ली, कन्नौज, लखनऊ, कानपुर आदि में खपता है। लगभग संपूर्ण तेल सौंदर्य प्रसाधनों में प्रयुक्त होता है।

प्रशिक्षण एवं अनुसंधान

चंदन की खेती हेतु काष्ठ विज्ञान एवं प्रौद्योगिकी संस्थान, बैगलुरू द्वारा वर्ष में दो बार प्रशिक्षण कार्यक्रम आयोजित किया जाता है। इस हेतु काष्ठ विज्ञान एवं प्रौद्योगिकी संस्थान, बैगलुरू की बेवसाइट पर जानकारी दी जाती है। इस संस्थान से उच्च गुणवत्ता वाले प्रमाणित बीज भी विक्रय के लिये उपलब्ध होते हैं।

अकेसिया कटेचू का भौगोलिक वितरण एवं आर्थिक महत्व

डॉ. ननिता बेरी एवं कुवेर सिंह जाटव

वनसंवर्धन वन प्रबंधन एवं कृषि वानिकी प्रभाग
भा.वा.अ.शि.प-उष्णकटिबंधीय वन अनुसंधान संस्थान,
जबलपुर (म॰प्र॰) 482021

परिचय

अकेसिया कटेचू (एल.एफ.) एशिया में अत्यधिक उपयोग किया जाने वाला पारंपरिक औषधीय वृक्ष है। जिसके हार्टवुड के चूर्ण का उपयोग कत्था बनाने में किया जाता है जो कि प्रोटीन एवं पेप्टाइड्स का प्रमुख स्त्रोत हैं।

उष्णकटिबंधीय वन एक समय उष्णकटिबंधीय क्षेत्र के कुल क्षेत्रफल के आधे से अधिक हिस्से पर आच्छादित थे (जेनज़ेन, 1988), लेकिन पिछले दशक के दौरान यह वन धीरे- धीरे निर्वनीकरण होते गए (सागर और सिंह, 2005)। भारत देश में, कुल भौगोलिक क्षेत्र का लगभग 21.71 प्रतिशत हिस्सा वनों से घिरा है (एफ.एस.आई., 2021)। वैश्विक स्तर पर, वनों के कुल क्षेत्रफल में से 52 प्रतिशत उष्णकटिबंधीय वन हैं (सिंह और सिंह, 1988)। विभिन्न प्रकार के वनों में, उष्णकटिबंधीय वन करीब 25 प्रतिशत कार्बन अवशोषित करते हैं (बोनान, 2008), जो कि पृथ्वी पर जलवायु गतिशीलता को विनियमित करने में प्रमुख भूमिका निभाते हैं (लुईस एट अल., 2009; झोउ एट अल, 2013)। इस प्रकार उष्णकटिबंधीय वन, वैश्विक कार्बन संतुलन, जैव विविधता संरक्षण में महत्वपूर्ण भूमिका निभाते हैं और अन्य मूल्यवान पर्यावरणीय सेवाएं भी प्रदान करते हैं। इसके अलावा यह वन पारिस्थितिकी संसाधनों का भंडार हैं और दुनिया भर में लाखों लोगों के जीवन को बनाए रखते हैं। उष्णकटिबंधीय शुष्क पर्णपाती वन सूखे जैसी कठिन परिस्थितियों में कमजोर परिवारों के भरण-पोषण के लिए विशेष रूप से वरदान हैं (ब्लैकी एट अल., 2014) क्योंकि इनमे औषधीय और आर्थिक रूप से महत्वपूर्ण वृक्ष प्रचुर मात्रा में उपलब्ध होते हैं लेकिन इन बहुमूल्य प्रजाति के अत्यधिक विदोहन जमीन का विभिन्न उद्देश्यों में उपयोग, जैविक आक्रमण (कुमार एट अल., 2021) और जलवायु परिवर्तन के कारण यह वन (उष्णकटिबंधीय शुष्क पर्णपाती) लगातार घट रहे हैं (ब्लैकी एट अल., 2014)। इस प्रकार, उत्तरी उष्णकटिबंधीय शुष्क पर्णपाती वन की प्रजातियों की संरचना और विविधता, कार्बन अवशोषण क्षमता, जनसंख्या संरचना और मिट्टी के स्वास्थ्य की स्थिति पर एक अध्ययन वन प्रबंधन में उपयोगी होने के अलावा पारिस्थितिकी रूप से भी महत्वपूर्ण है।

उष्णकटिबंधीय वन पृथ्वी पर पाई जाने वाली पौधों की प्रजातियों की अधिकतम विविधता को भी आश्रय देते हैं (डब्ल्यू सी.एम.सी, 1992)।

उष्णकटिबंधीय वन क्षेत्र में खैर प्रजाति का भी प्राकृतिक वितरण देखा जा सकता है। 'खैर', ग्रीक शब्द 'अकिस' से आया है, जिसका अर्थ है बिंदु या एक कंटीला इस प्रजाति का नाम 'कच्छ' से आया है, जो हार्टवुड से अलग किया गया एक टैनिंग अर्क है।

वानस्पतिक वर्णन

खैर मध्यम आकार का 15 मीटर तक ऊँचा कांटेदार वृक्ष है, इसकी छाल गहरे भूरे रंग की होती है, जो लंबी धारियों या कभी-कभी संकीर्ण आयताकार पट्टी में निकलती है, इसकी हार्टवुड

भूरी या लाल होती है, शाखाएँ पतली, नए कोमलयुक्त चमकदार तथा 2 चक्र वाली होती है। पत्तियाँ द्विपक्षीय रूप से मिश्रित होती हैं, जिनमें 9 - 30 जोड़ी पिन्ना और रेचिस एक ग्रंथि होती है; पत्रक 16-50 जोड़े, आयताकार-रैखिक, 2-6 मिमी लंबे, चिकने यायौवन फूल 5-10 सेमी लंबे अक्षीय स्पाइक्स में, पेंटामेरस, सफेद से हल्के पीले रंग के,एक कैम्पैनुलेट कैलीक्स के साथ, 1-1.5 मि.मी. लंबा, और एक कोरोला 2.5-3 मि.मी. लंबा; पुंकेसर असंख्य, कोरोला से बहुत दूर तक फैले हुए, सफेद या पीले-सफेद तंतुओं के साथ। फल एक पट्टा के आकार का, 5-8.5 सेमी. x 1 - 1.5 सेमी., चपटा, दोनों सिरों पर पतला, चमकदार, भूरा, स्फुटित, 3-10 बीजयुक्त; बीज मोटे तौर पर अंडाकार होते हैं।

उत्तरी भारत में, खैर वृक्ष की पत्तियाँ फरवरी में गिर जाती हैं और अप्रैल या मई के दौरान नई पत्तियाँ दिखाई देने लगती हैं। नये पत्तों के साथ फूल भी आते हैं। जुलाई या अगस्त तक पेड़ों पर फूल आते रहते हैं। फलियाँ तेजी से विकसित होती हैं, सितंबर या अक्टूबर तक पूर्ण आकार तक पहुँच जाती हैं और हरे से लाल-हरे और फिर भूरे रंग में बदल जाती हैं; वे नवंबर के अंत से जनवरी की शुरुआत तक पकना शुरू कर देते हैं। फलियाँ पकने के कुछ समय बाद जनवरी महीने में गिरना शुरू हो जाती हैं जो अगले महीनों तक गिरती रहती हैं। कुछ फलियाँ अगले अक्टूबर तक पेड़ पर बनी रहती हैं लेकिन कीड़ें द्वारा बीज अत्यधिक क्षतिग्रस्त हो जाते है। इसके बीज हवा से फैलने के कारण बारिश की शुरुआत के साथ अंकुरित होते हैं।

मिट्टी का प्रकार

यह प्रजाति विभिन्न प्रकार की मिट्टी जैसे रेतीली, चिकनी, काली, कंकरीली, जलोढ़ और दोमट मिट्टी में उगती है। यह वृक्ष उथली मिट्टी में भी उगने में सक्षम है।

प्रजाति का भौगोलिक वितरण

खैर प्रजाति के महत्व को देखते हुए इसके भौगोलिक प्राकृतिक वितरण का आकलन केम्पा पोषित एफ.जी.आर. परियोजना के अंतर्गत महाराष्ट्र के वन क्षेत्रों का वृहत स्तर पर सर्वेक्षण किया गया और यह पाया गया कि यह प्रजाति महाराष्ट्र के जलगांव (17.14 प्रतिशत), नासिक (14.08 प्रतिशत), गड़चिरोली (14.04 प्रतिशत), नागपुर (13.85 प्रतिशत) कोल्हापुर (13.98 प्रतिशत), सतारा (13.94 प्रतिशत), चंद्रपुर (10.64 प्रतिशत) एवं यवतमाल (9.26 प्रतिशत) के वनों में प्राकृतिक रूप से आच्छादित है।

खैर वृक्ष का महत्व

भोजन

बीजों में पानी में घुलनशील श्लेष्मा (6.8 प्रतिशत) होता है; यह प्रोटीन और पोषण की दृष्टि से अच्छा स्रोत है।

चारा

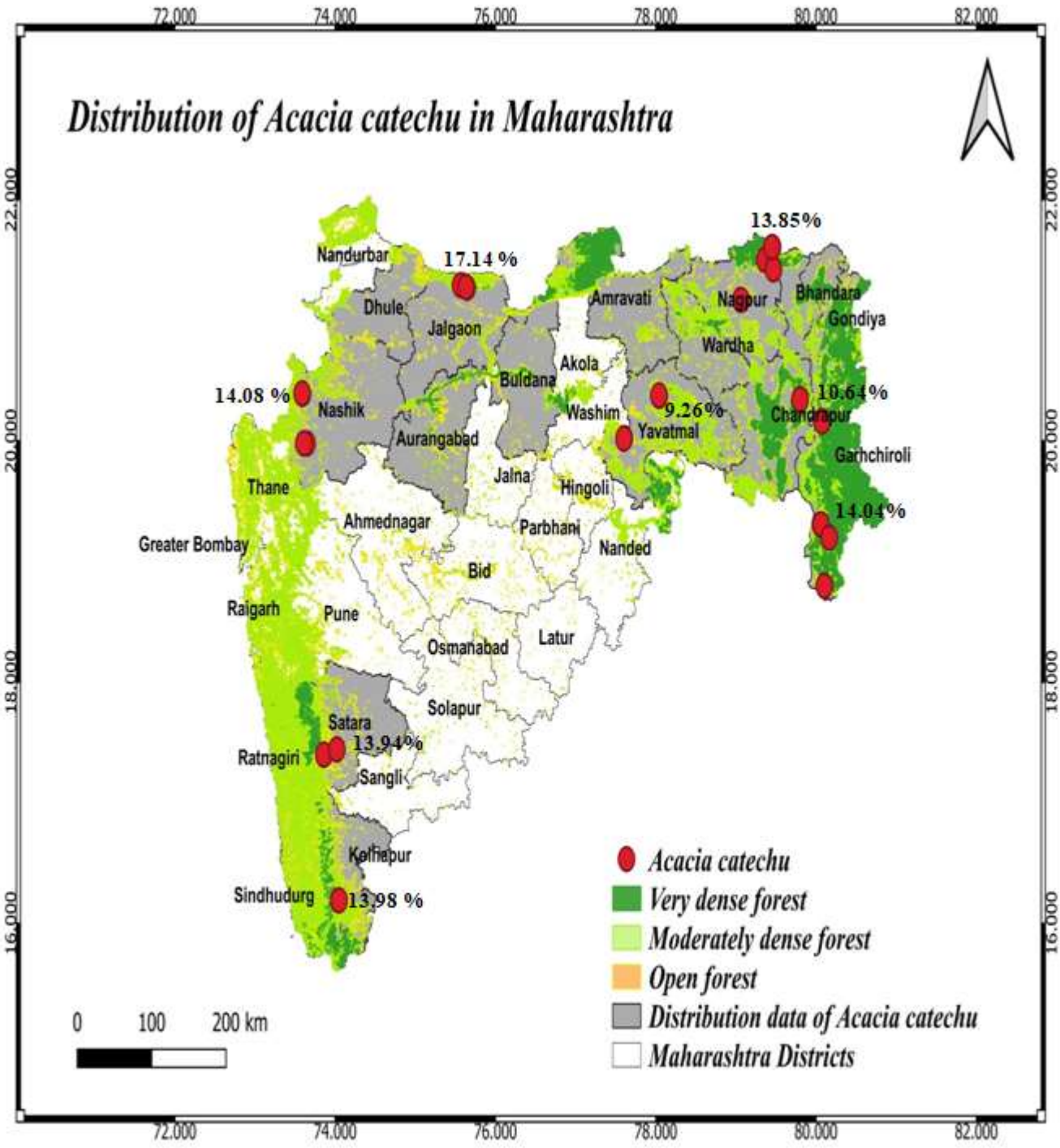
इसे चारा के लिए अच्छा वृक्ष माना जाता है और इसे बड़े पैमाने पर बकरियों और मवेशियों को खिलाने के लिए काटा जाता है। पतली नर्म शाखाओं को आमतौर पर मुख्य पत्ती गिरने से पहले काट दिया जाता है जो कि चारे के रूप में उपयोगी है।

ईंधन

खैर की लकड़ी, एक उत्कृष्ट जलाऊ और चारकोल के लिए सबसे अच्छी लकड़ियों में से एक है तथा इसके सैपवुड का ऊष्मीय मान 5142 किलो कैलोरी प्रति किग्रा एवं हार्टवुड 5244 किलो कैलोरी प्रति किग्रा होती है। लकड़ी को जलाने पर 38.10 प्रतिशत बहुत अच्छी गुणवत्ता का कोयला प्राप्त होता है।

इमारती लकड़ी

खैर की लकड़ी, बहुत मजबूत, टिकाऊ और सफेद चींटियों के प्रति प्रतिरोधी है। कत्था निकालने के



अकेसिया कटेचू (खैर) का महाराष्ट्र वन क्षेत्र में भौगोलिक वितरण

अकेसिया कटेचू (खैर) की छाया चित्र

महाराष्ट्र के वन क्षेत्र में खैर का सर्वेक्षण एवं आकलन करते हुए

बाद बचे हुए कच् का उपयोग हार्डबोर्ड के निर्माण के लिए किया जाता है।

कृषि उपकरणों मे

लकड़ी का उपयोग घरेलू खंभों, घर की चौकियों, कृषि उपकरणों और पहियों के लिए किया जाता है।

टैनिन या रंग(डाई)

खैर वृक्ष से कच् नामक पदार्थ को हार्टवुड से अलग किया जाता है। जिसे ठोस अर्क के रूप में विपणन किया जाता है। प्रसंस्करण के तरीके के आधार पर कच्चे कच् से कई उत्पाद प्राप्त किए जा सकते हैं। डार्क कैटेचू या पेगु कच् का उपयोग चमड़े के भूरे रंग के सामान के मिश्रण को रंगने के लिए किया जाता है। कत्था के अर्क का उपयोग रेशम, कपास, कैनवास, कागज और चमड़ा को गहरे-भूरे रंग में रंगाई के लिए भी किया जाता है।

गोंद या राल

छाल से बहुत अच्छी गुणवत्ता का हल्का गोंद निकलता है और यह अरेबिक गोंद के सर्वोत्तम विकल्पों में से एक है।

विष

इसकी छाल को विषैला माना जाता है, यह क्षारीय होता है तथा फल और तने दोनों का

उपयोग म्यांमार में मछली को विष देने के लिए किया जाता है।

औषधि

खेरसल, कच् का एक क्रिस्टलीय रूप है जो कभी-कभी लकड़ी की गुहाओं में जमा पाया जाता है, जिसका औषधी उपयोग खांसी और गले की खराश के रूप में किया जाता है तथा इसकी छाल पेचिश, दस्त, घाव और उपचार में भी प्रभावी होती है। इनके बीजों में जीवाणुरोधी अवयव पाया जाता है। छाल के चूर्ण को अंडे की जर्दी और कॉपर सल्फेट के साथ मिलाकर **कैंसर** कोशिका की वृद्धि रोकने के लिए किया जाता है।

जैव सुरक्षा

खैर की कांटेदार शाखाएं, खेतों के लिए बाड़ के रूप में काम करती हैं।

कीट और बीमारियाँ

जीनस कुस्कुटा परजीवी और लोरैंथस के हेमिपैरासिटिक पौधे इस वृक्ष के शत्रु हैं। खैर के वृक्ष पर आक्रमण करने वाले कीड़ों में *बोथोगोनिया स्प.*, बीज छेदक भृंग जैसे ***ब्रुचिडस*** *टेरानस, ब्रुचस बिलिनेटोपाइगस* और पत्ती खाने वाला कीट *दासीचिरा मेंडोसा* शामिल हैं। बीटल *सिनोक्सिऑन एनाले* (शाखा और टहनी छेदक), यह कीट मुख्य रूप से कटे हुए सैपवुड, लॉग या रोगग्रस्त और कमजोर डंडों में छेद करता है लेकिन कभी-कभी यह खाने के लिए टहनियों और नए तनों में सुरंग बना देता है। कवक जैसे गैनोडर्मा ल्यूसिडम, जड़ सड़न का मुख्य कारण बनता है।

अन्य उत्पाद

कत्था के अर्क का उपयोग मछली पकड़ने के जाल, रस्सियों और तटवर्ती तेल कुओं में चिपचिपाहट संशोधक को संरक्षित करने के लिए किया जाता है। यह लाख के कीड़ों का पोषक भी वृक्ष है। इसके वृक्ष में एक शक्तिशाली **सुरक्षात्मक** श्लेष्म रस होता है, इसका सबसे **उल्लेखनीय** गुण इसकी जल धारण करने की शक्ति है।

इस प्रकार खैर वृक्ष के **महत्व** के आधार पर, इस प्रजाति को प्राकृतिक वनो में संरक्षित करने, वन विभाग एवं इस संस्थान **द्वारा** सतत् प्रयास किए जा रहे है। जरुरत है कि इन प्रजाति को वनों के बाहर भी संरक्षित किया जाए और इस वृक्ष से संबंधित जानकारी जनसमुदाय को प्रशिक्षण के माध्यम से ज्यादा से ज्यादा प्रदान की जाए।

Occurrence of larval parasitoids, *Apanteles* speciesinsal defoliator, *Lymantria mathura*

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Abstract

Lymantria mathura Moore (Lepidoptera: Lymantriidae) is a potential insect defoliator of sal, Shorea*robusta*Gaertn. f. (Family: Dipterocarpaceae). The larvae of *L. mathura*have recorded to be parasitized by *Apanteles* species in in sal forests of Odisha. The present article deals with diagnostic characters of *Apanteles* species identified on *L. mathura* and field parasitization potential of parasitoids.

Key words: Odisha, larval parasitoids, *Apanteles* species, sal defoliator, *Lymantria mathura*

Introduction

*Lymantria mathura*Moore (Lepidoptera: Lymantriidae) is commonly known as the rosy gypsy moth or pink gypsy moth. The female moth lay eggs in masses, usually on the tree trunks or stems or larger branches of the host. The larva reaches a length of 50 mm in the male and 90 mm in the female, colour ashy with yellow bands across the thorax, abdomen with rows of papules bearing tufts of long hairs, two long plumes of hair project on either side of the head (Beeson, 1941, Browne, 1968). Pupation takes place in a leaf fastened with a few stands of silk. The pupa is of the obtectadecticus type, and the appendages are firmly soldered to the body. It is buff to dark brown, about 20-36 mm long, and shows sexual dimorphism, the female pupa is paler, larger and heavier than the male (Molet, 2012). The moths are moderate in sized. There is marked sexual dimorphism in size and colour. The female is larger than male. The diagnostic characters of adult moths are described by different workers (Hampson, 1892; Beeson, 1941; Browne, 1968; Roonwal, 1979; Molet, 2012; Gurule, 2013, Roychoudhury et al., 2020a).

The larvae of *L. mathura*are found to be parasitized by *Apanteles* species in nature, as recorded by Roychoudhury (2013) and Roychoudhury et al. (2020b) in sal forests of Odisha. The genus *Apanteles* Foerster belongs to the order Hymenoptera, family Braconidae and sub-family Microgastrinae. The genus *Apanteles* is the most conspicuous single group of endo-parasitoids of Lepidoptera in the world, both in terms of species richness and economic importance. In India, considerable work has been carried out on identification of *Apanteles* species (Wilkinson, 1928a, b).*Apanteles* species are well distributed in central India (Roychoudhury, 2010, 2013, 2016; Roychoudhury*et al.*, 2020b). The present article deals with *A.ashmeadi*,*A. calycinae*, *A. endymion*, *A. fuscinervis*, *A.hemitheae*, *A.hyposidrae* and *A.obliquae* as parasitoids of sal defoliator, *L. mathura.* The diagnostic characters and parasitization

potential of these *Apantelesspecies* are mentioned as hereunder.

***Apantelesashmeadi* Wilkinson**

Apantelesashmeadi Wilkinson, 1928a: 87

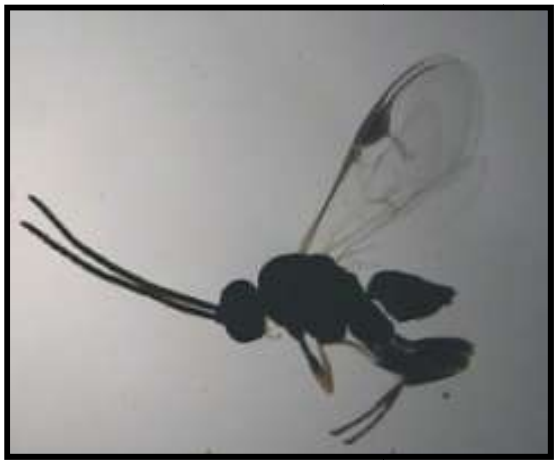

Fig.1: *Apanteles ashmeadi*

Diagnostic characters

Fore-wings with breadth of stigma, first abscissa of radial, equal to or rather less than the breadth of stigma roundly angled with and rather longer than the transverse cubital which latter is about equal to the recurrent all nearly equal; apical portion of first abscissa of cubital shorter than recurrent but longer than the pigmented portion of second abscissa of cubital, and also equal than the upper portion of basal vein; stigma shorter than metacarp. First abdominal tergite and second tergite apparently very finely and sparsely punctuate round the margins of the apical quarter; ovipositor sheaths are longer than hind tibial spur.

***Apanteles calycinae* Wilkinson**

Apantelescalycinae Wilkinson, 1928a: 113

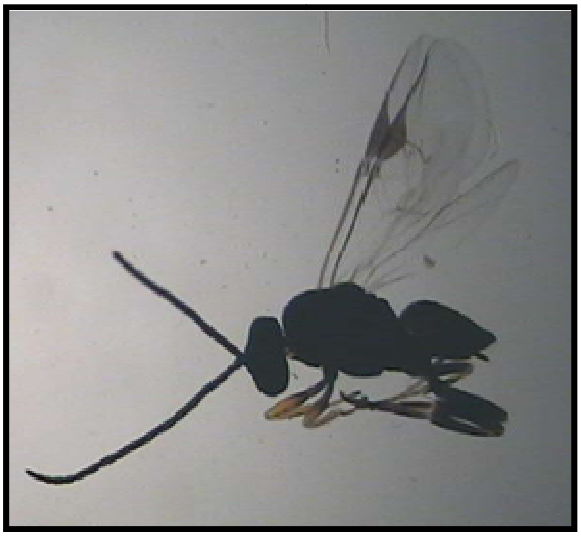

Fig.2: *Apanteles calycinae*

Diagnostic characters

Fore-wings with first abscissa of radial about equal to the breadth of stigma and transverse cubital all about equal, the recurrent just slightly shorter; the apical portion of first abscissa of the cubital definitely shorter than the recurret, a little longer than the upper portionof basal vein about equal to the pigmented portion of the second abscissa of the cubital. Pterostigma is shorter than the metacarp. In hind legs, longer tibial spur half and shorter spur is third the length of basal joint of hind tarsus. First abdominal tergite finely and rather indefinitely punctuate in apical half, with some definitely stronger sculpturing towards apex medially; ovipositor sheaths shorter than the shorter hind tibial spur.

***Apanteles endymion* Wilkinson**

Apanteles endymion Wilkinson, 1928b : 322

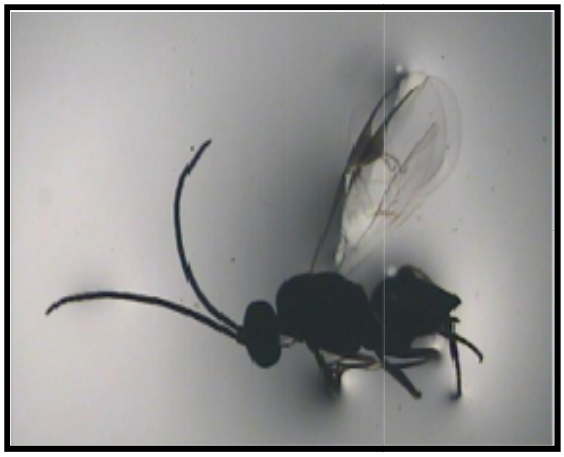

Fig.3: ***Apanteles endymion***

Diagnostic features

Fore-wings with first abscissa of radial and transverse cubital straight, distinctly angled with each other,their point of junction normally slightly thickened, more usually equal to each other in length but often the radial rather longer than the transverse cubital which is four fifths the breadth of the stigma, equal to the recurrent and 1.5 times as long as the apical portion of the first abscissa of the cubital is shorter than transverse cubital,this latter equal to or rather longer than the pigmented portion of the second abscissa of cubital; the upper portion of basal vein shor; pterostigma is equal than metacarp. In hind legs, longer tibial spur half and shorter spur is two fifth the length of basal joint of hind tarsus. First tergite shining smooth to minutely and very indefinitely sculptured, and with some, indefinite, punctuation in and apical fourth, very decidedly turned over and dawn but medially not tumescent, in the basal half of the tergite. Apical breadth of the tergite is equal to its breadth at thebase of the apical half, is less than its breadth at the middle of the apical half, and is greater than the breadth of its extreme base (18:18:20:16), Ovipositor sheaths barely longer than basal joint of hind tarsus. The median length apparently about 1.4 times the apical breadth (25:18). Second tergite with an occasional minute puncture, its apical margin very slightly curved to nearly its lateral sulci widely divergent at extreme base and then nearly parallel.

***Apanteles fuscinervis* Cameron**

*Apantelesfuscinervis*Cameron, 1911 : 207

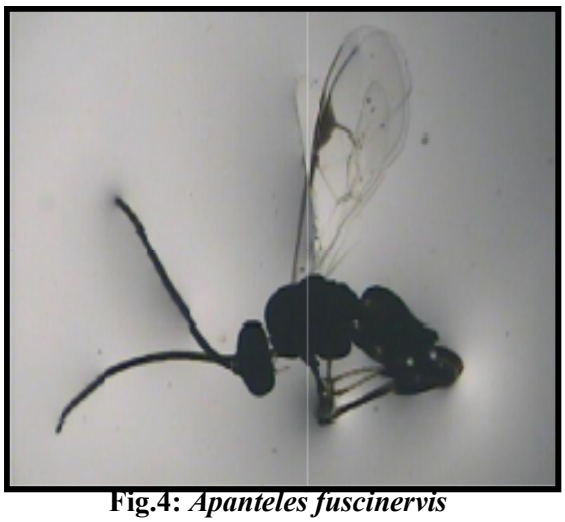

Fig.4: ***Apanteles fuscinervis***

Diagnostic characters

Fore wing with first abscissa of radial and transverse cubital distinctly angled. Upper portion of the basal vein short, distinctly shorter than pigmented portion of the second abscissa of cubital. Metacarp rarely longer than pterostigma. In hind legs, longer tibial spur half of hind besitarsus& shorter tibial spur 1/3 of hind besitarsus. First tergite long its lateral margins quite straight and regularly converging to the truncate apex, its median length quite twice its basal breath and quite four times its apical breadth; Second tergite with its base rather narrower than the apex of the first tergite and its width median length just shorter than its own apical breadth. 3rd tergite much longer than the 2nd tergite. ovipositor sheath shorter than hind tibia.

***Apanteles hemitheae* Wilkinson**

*Apantelesheamitheae*Wilkinson, 1928b: 124

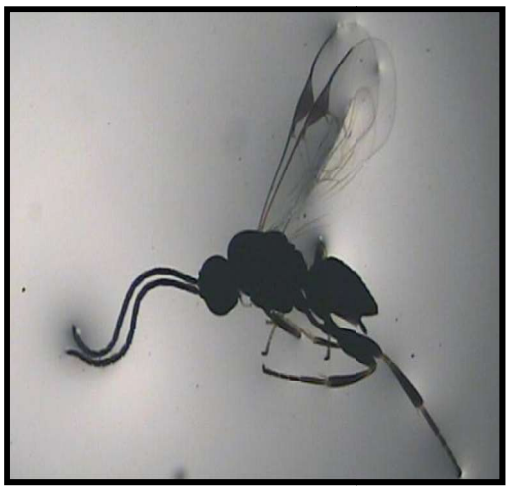

Fig.5: ***Apanteles hemitheae***

Diagnostic characters

Fore-wings with first abscissa of radial and recurrent of equal length just shorter than the breadth of stigma, rather apical portion of first abscissa of the cubital is shorter than transverse cubital, longer than the pigmented portion of the second abscissa of cubital; this latter being just half the length of the transverse cubital but longer than the upper portion of basal vein; pterostigma is shorter than metacarp. In hind legs, longer tibial spur half and shorter spur is third the length of basal joint of hind tarsus. Ovipositor sheaths are shorter than basal joint of hind tarsus.

***Apanteleshyposidrae* Wilkinson**

Apanteleshyposidrae Wilkinson, 1928a: 125

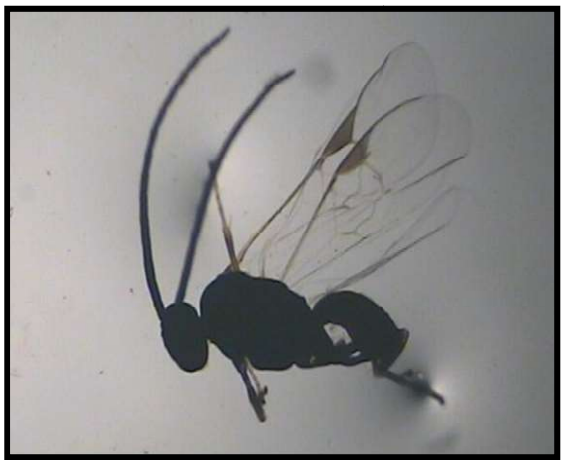

Fig.6: ***Apanteles hyposidrae***

Diagnostic characters: Fore-wings with first abscissa of radial and evenly rounded With and hardly differentiated from, the transverse cubital; recurrent, rather variable but usually just shorter than or equal to width of stigma. Apical portion of first abscissa of cubital is equal to pigmented portion of second abscissa of cubital. Stigma is shorter than metacarp. First tergite in apical half more or less rugosely striate with some strong punctures, second tergite more often very indefinitely sculptured in apical half, but occasionally rather indefinitely, very weakly, longitudinally striate, Ovipositor sheaths are shorter than hind tarsus.

***Apanteles obliquae* Wilkinson**

Apanteles obliquae Wilkinson, 1928a: 82

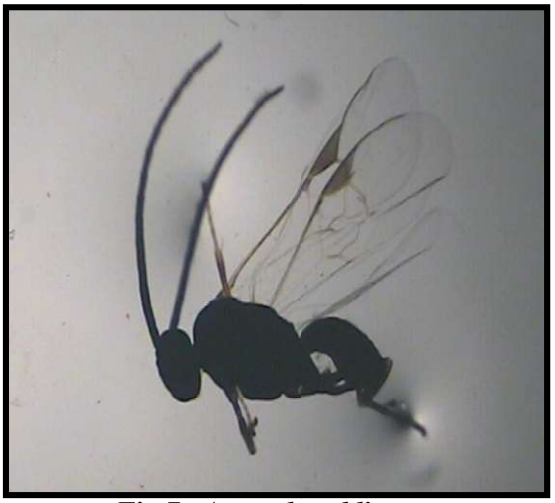

Fig.7: ***Apanteles obliquae***

Diagnostic characters

Female, fore wings with first abscissa of radial with transverse cubital always apparent length of abscissa of radial equal to the than breadth of stigma; longer than transverse cubital which latter `equal to recurrent ; or transverse cubital and breadth of stigma equal in length; breadth of stigma and recurren equal in lenth ; recurrent longer than the apical portion of first abscissa of cubital, which is much longer than pigmented portion of second

abscissa of cubital;this latter being about equal to the upper portion of basal vein; Width of stigma longer than vein. Stigma shorter than metacarp; first metasomal tergite is punctures and sculpture in the apical quarter.

Field parasitization of *Apanteles* species on *L. matura*

Based on the emergence of *Apanteles* species, the natural field parasitisation percentage of different species on target insect pests revealed that *A. hemitheae*showed the highestparasitisation (33.33%), followed by *A. fuscinervis*(25.00%), *A. endymion* (17.33%), *A. ashmeadi*(11.11%), *A. calycinae*and*A. obliquae* (8.33%) and A.*hyposidrae*(2.00%) (Roychoudhury, 2013; Roychoudhury et al., 2020b). The field parasitisation and laboratory tests play an important role in the selection of bio-control agent for the classical biological control strategy of an insect pest.

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